EJSM Science Overview

Bob Pappalardo

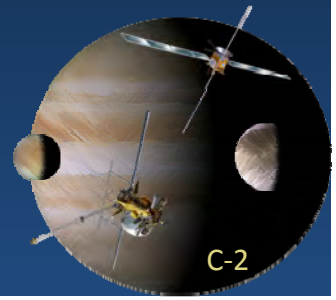
JEO Pre-Project Scientist, JPL/Caltech, Pasadena

Michele Dougherty

JSDT Co-Chair, Imperial College, London

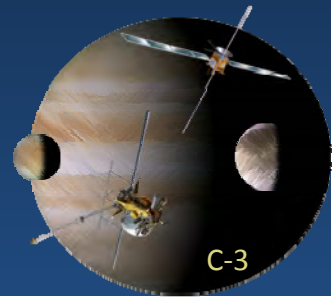
The Jupiter System: Planetary Superlatives

- Largest planet

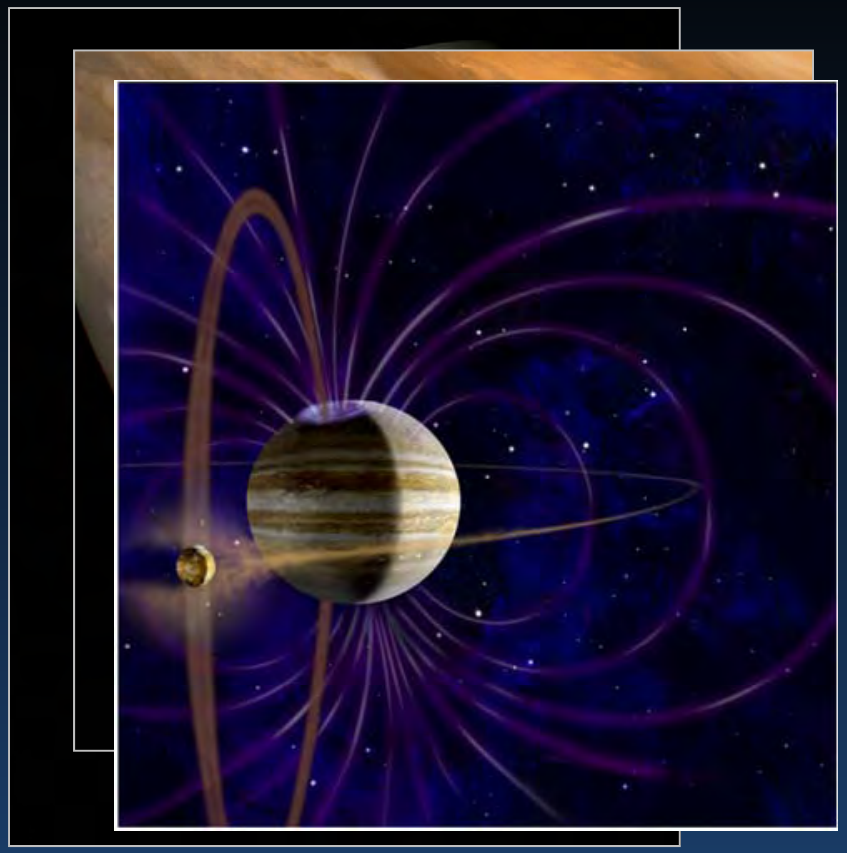


The Jupiter System: Planetary Superlatives

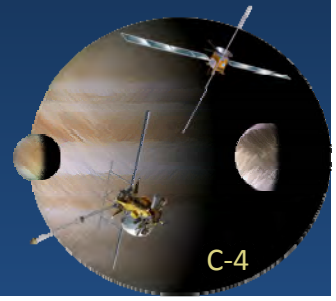
- Largest planet
- Most active atmosphere



The Jupiter System: Planetary Superlatives

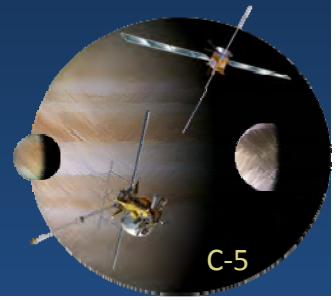


- Largest planet
- Most active atmosphere
- Most powerful magnetosphere



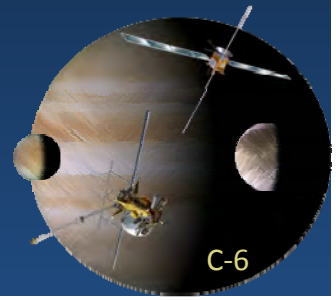
The Jupiter System: Planetary Superlatives

- Largest planet
- Most active atmosphere
- Most powerful magnetosphere
- Most volcanically active world



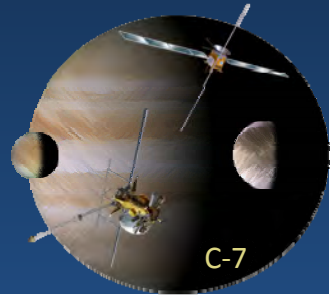
The Jupiter System: Planetary Superlatives

- Largest planet
- Most active atmosphere
- Most powerful magnetosphere
- Most volcanically active world
- Least active (most primitive) large moon

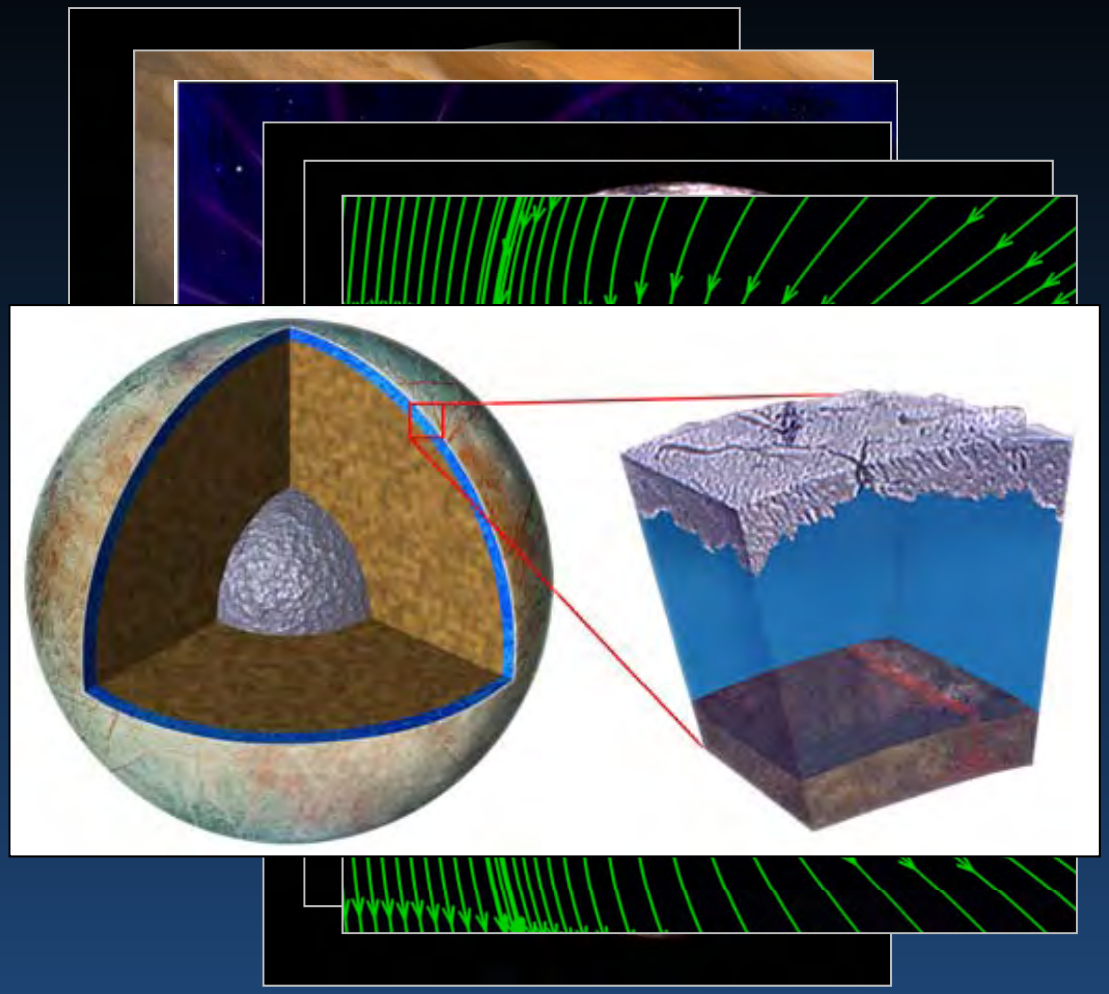


The Jupiter System: Planetary Superlatives

- Largest planet
- Most active atmosphere
- Most powerful magnetosphere
- Most volcanically active world
- Least active (most primitive) large moon
- Largest moon, and a magnetosphere

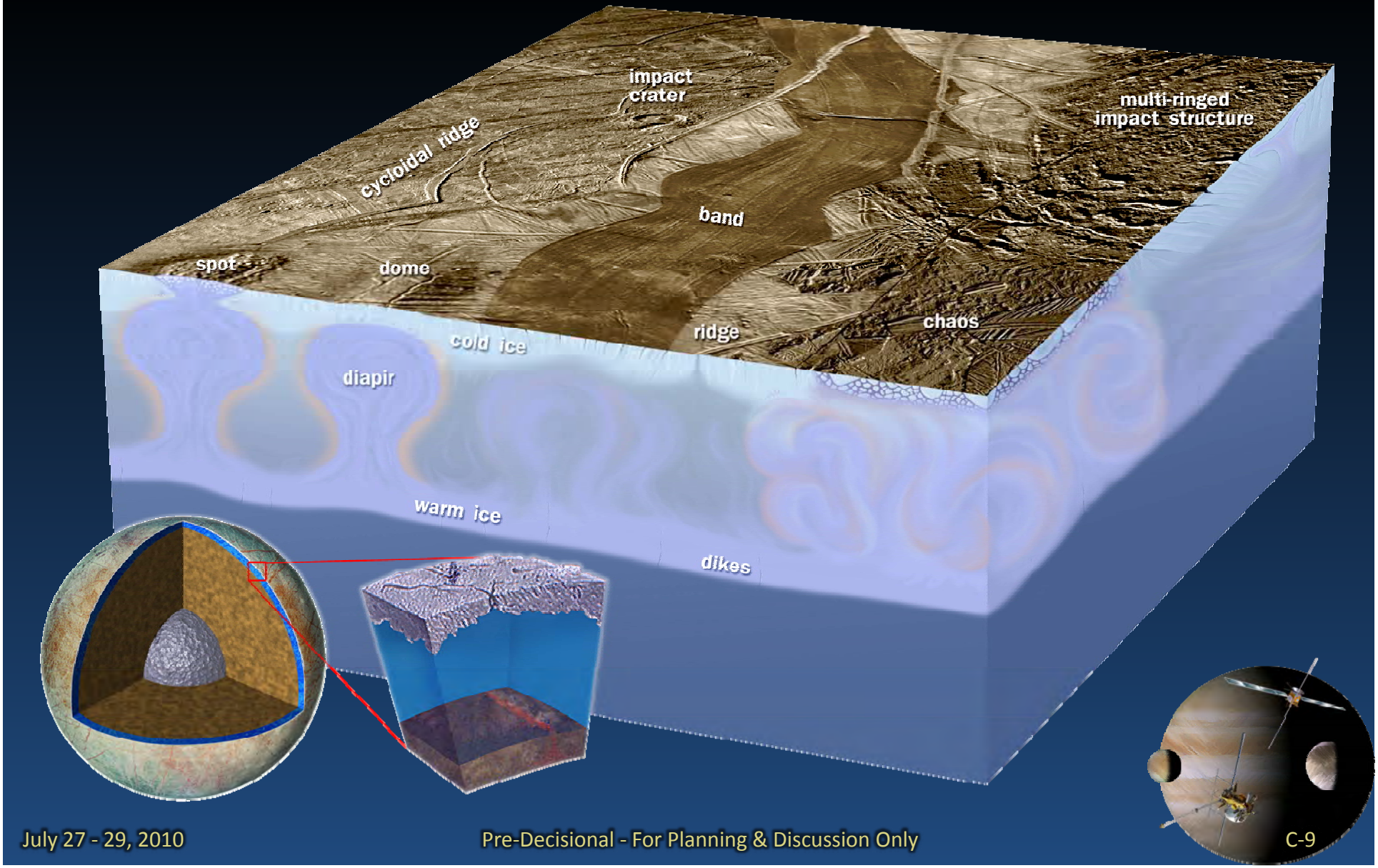


The Jupiter System: Planetary Superlatives

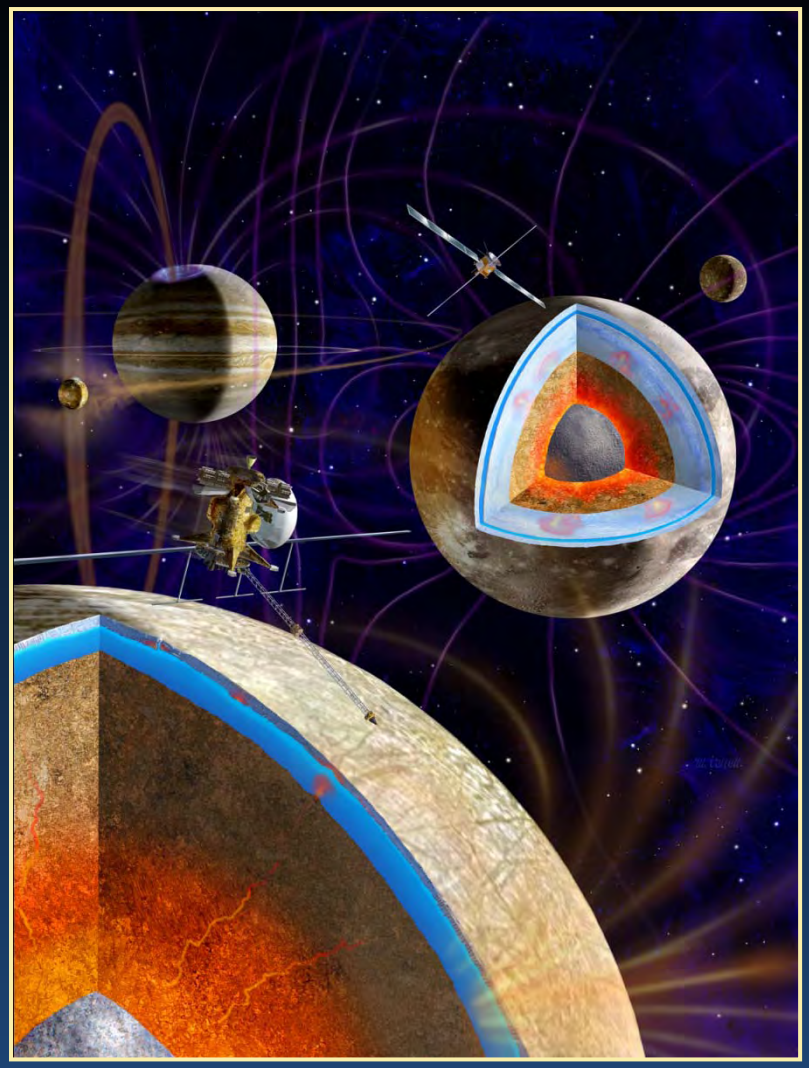


- Largest planet
- Most active atmosphere
- Most powerful magnetosphere
- Most volcanically active world
- Least active (most primitive) large moon
- Largest moon, and a magnetosphere
- Best chance for life?

Europa: Astrobiological and Geophysical Wonderland



Europa Jupiter System Mission

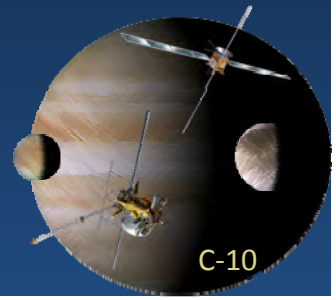


Key Questions:

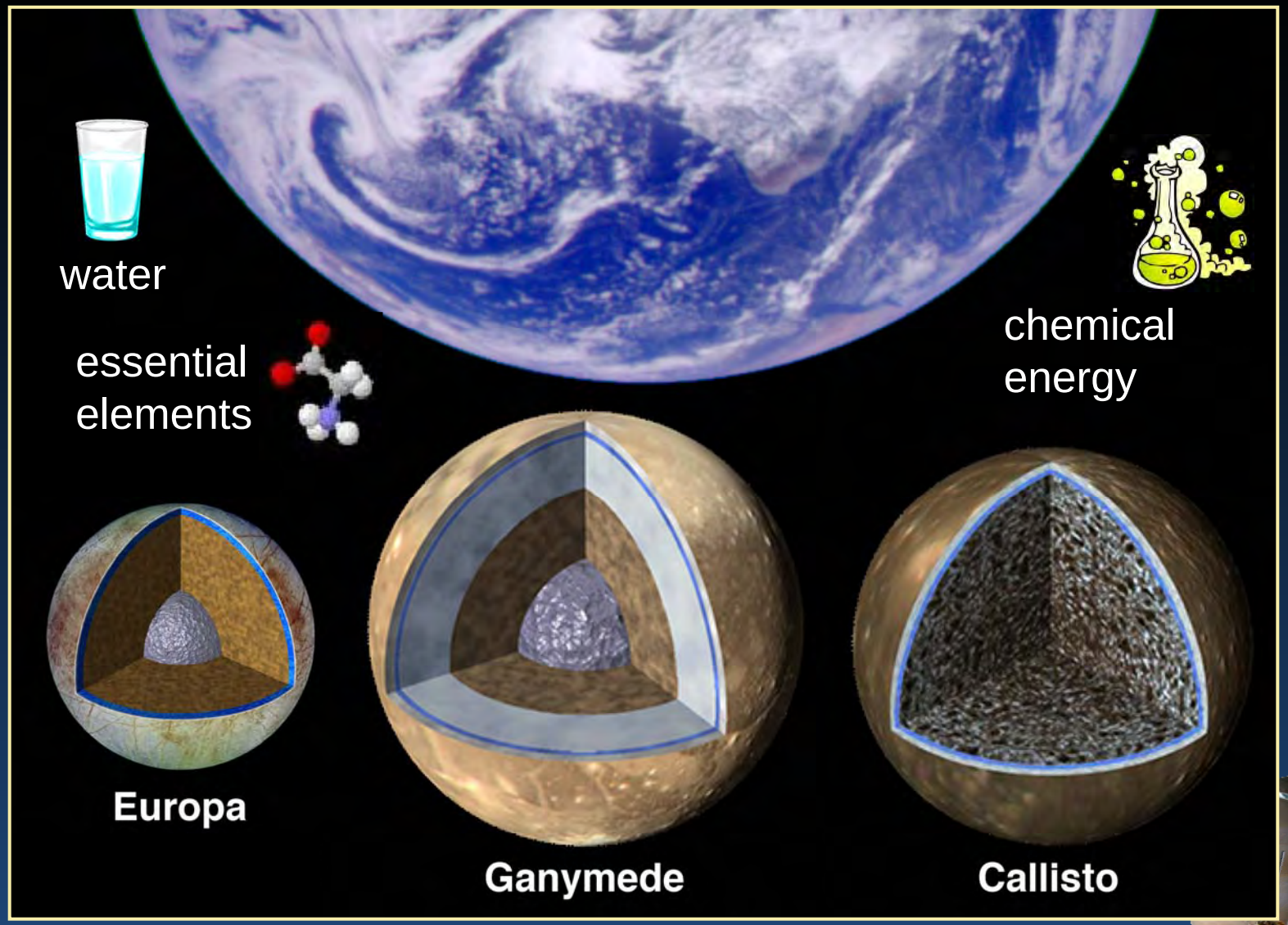
- Does the Jupiter system harbor habitable worlds?
- What are the processes operating within the Jupiter system?

Overarching Theme:

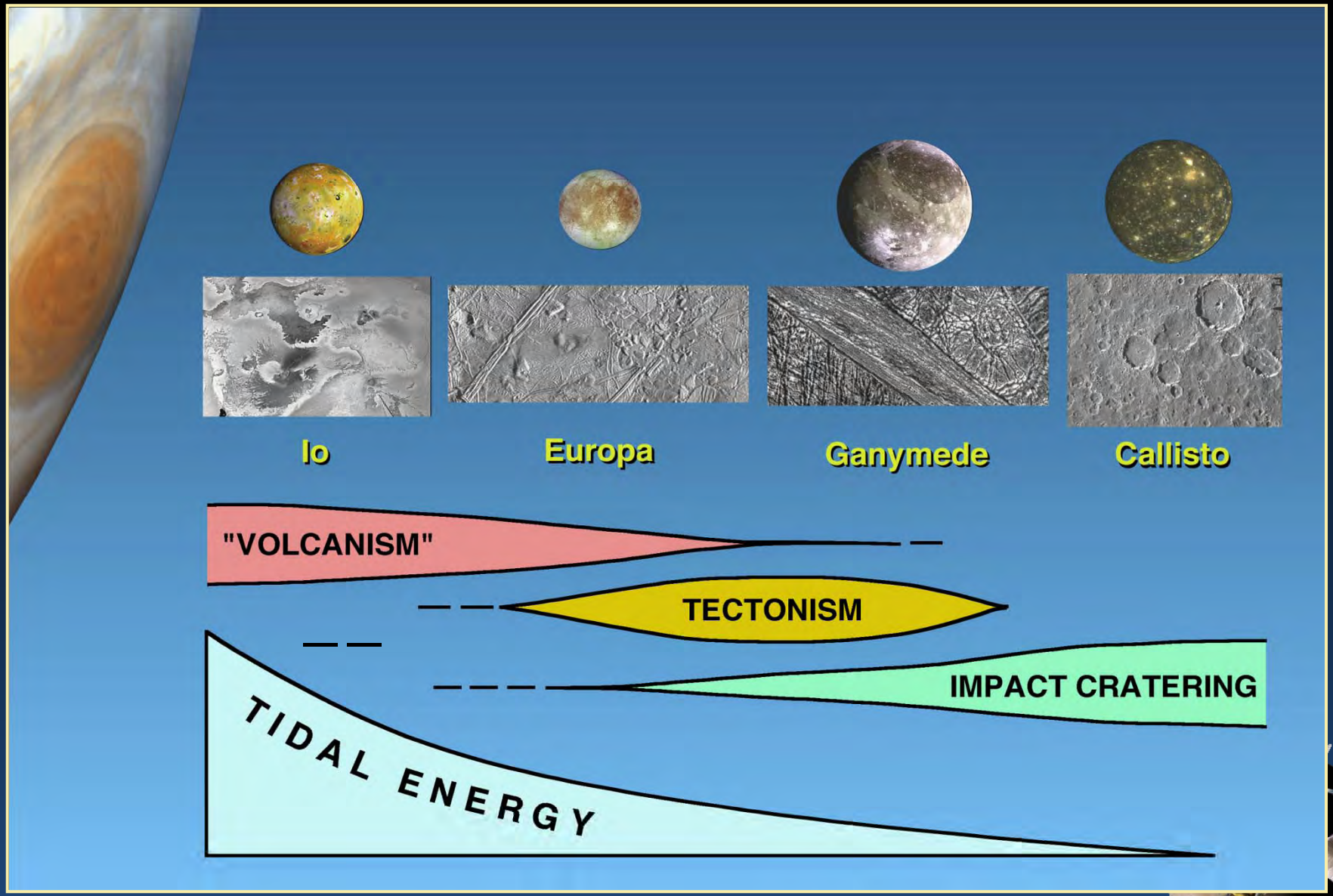
The Emergence of Habitable Worlds Around Gas Giants



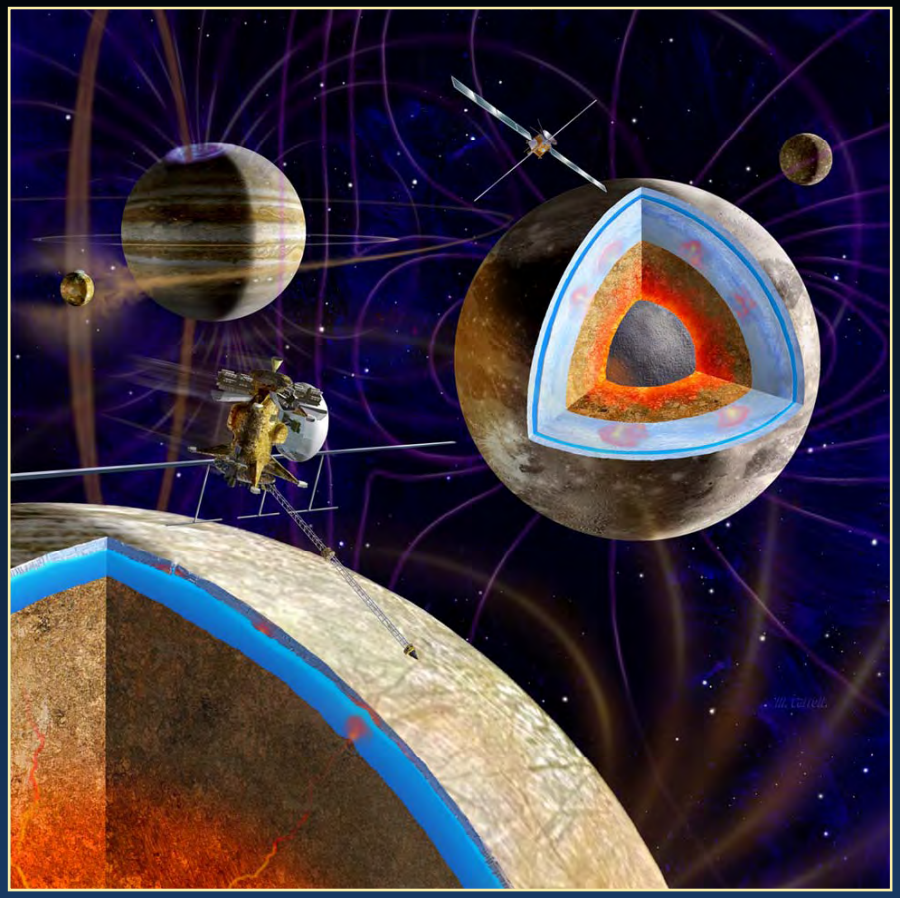
Habitable Worlds?

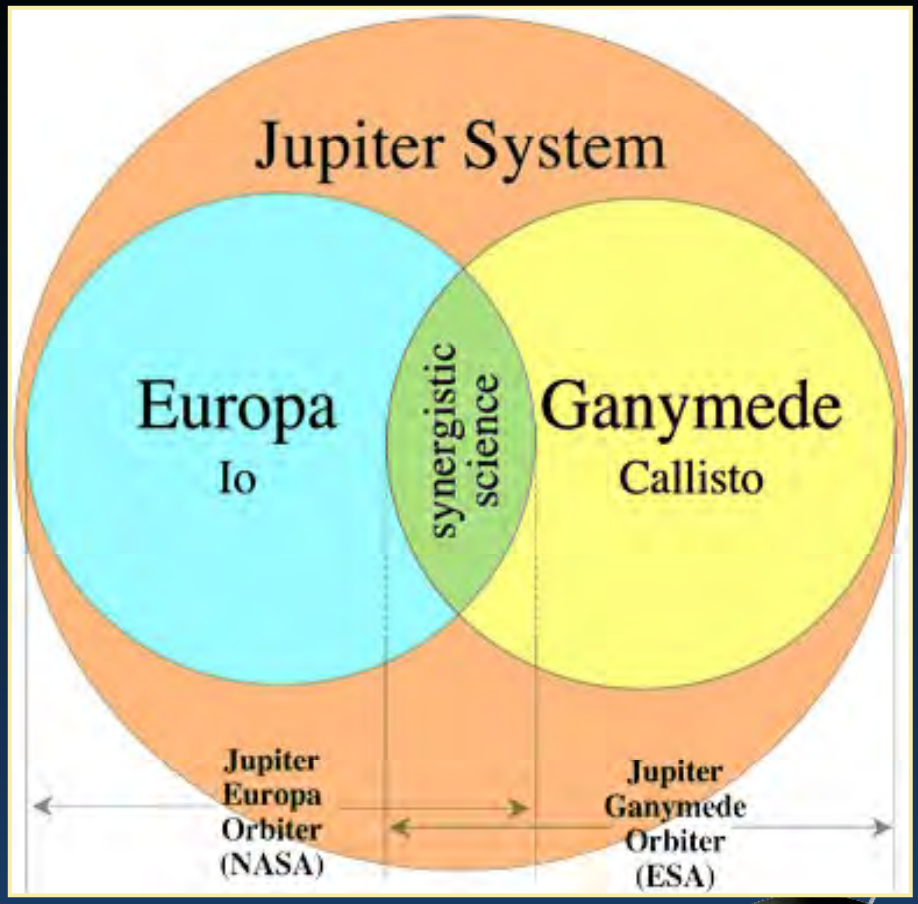


Planetary Processes

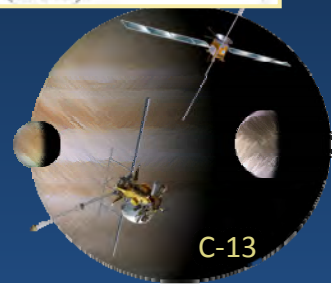


Europa Jupiter System Mission





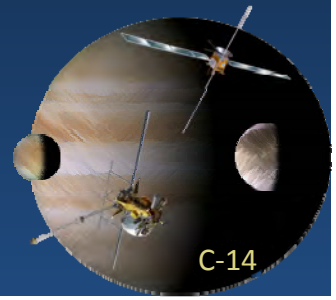
EJSM synergistic science: "1 + 1 = 3"



Science Definition Team 2010 Charter

- Recommend the science as a hierarchy of:
  - Goals, Objectives, Investigations, Measurements
- Advise on model instrument payloads
- Produce traceability matrix linking:
  - science, model payloads, ops scenarios, mission requirements
- Describe science-derived requirements
- Iterate science requirements within study constraints
- Improve definition and fidelity of dual-spacecraft synergistic science
- Refine science requirements for Jovian tour

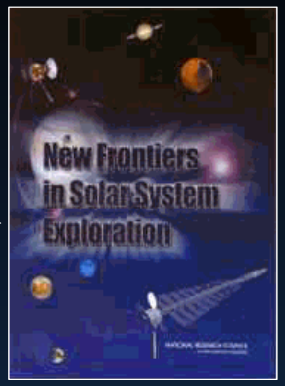
JSDT finalizes its work this calendar year



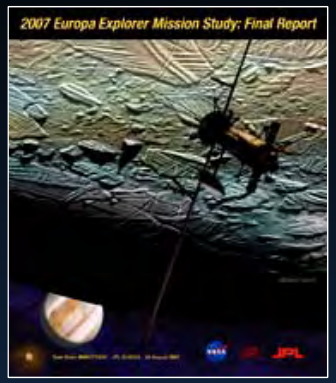
Evolution of EJSM Science Goals and Objectives

NASA, NRC, community reports

NRC Decadal Survey (2003)

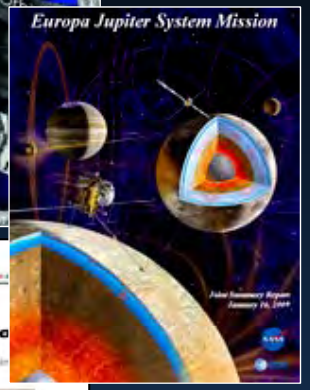


Europa Explorer report (2007)



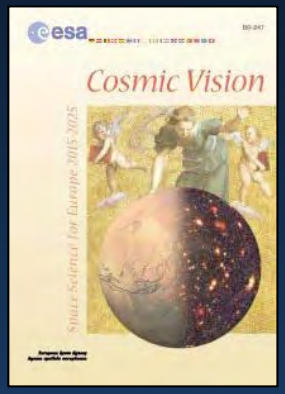
JEO final report (2008)

EJSM Joint Summary report (2008)



NRC Decadal Survey (2011)

European community reports



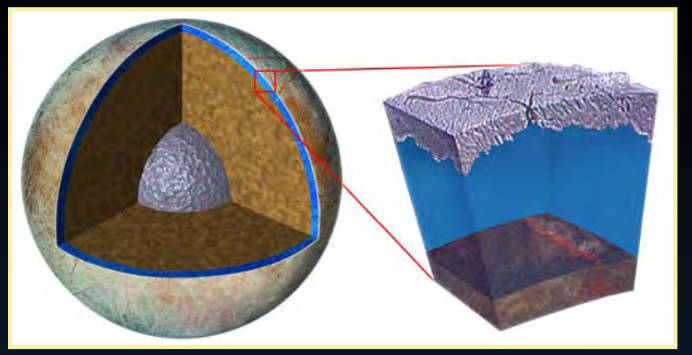
ESA Cosmic Vision (2005)

JGO final report (2008)

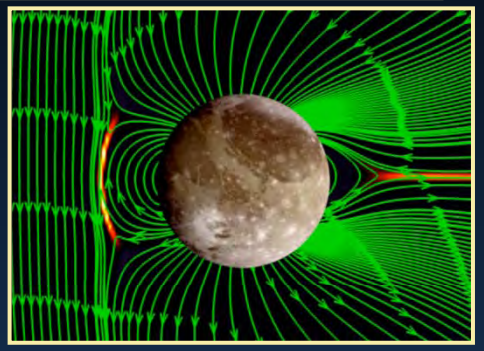
Mature science flowing from guiding documents &community input

EJSM Goals

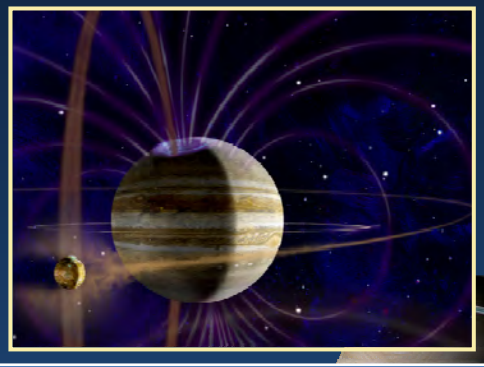
1. **Europa (JEO-focus):** Explore Europa to investigate its habitability



2. **Ganymede (JGO focus):** Characterize Ganymede as a planetary object including its potential habitability



3. **Jupiter System (JEO + JGO):** Explore the Jupiter system as an archetype for gas giants



EJSM addresses key Decadal Survey science priorities

Science Traceability Structure: Theme —> Model Instruments

Theme → The emergence of habitable worlds around gas giants.

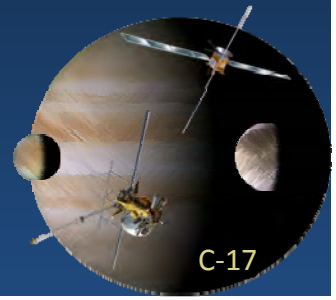
Goals → Explore Europa to investigate its habitability.

Objectives → Determine surface compositions and chemistry…

Investigations → Characterize surface organic and inorganic chemistry…

Example Measurements → Surface reflectance measurements … through a spectral range of…

Model Instruments → Infrared spectrometer…



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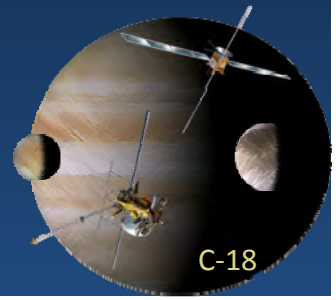
Defined by JJSDT

Examples presented by JJSDT



EJSM Traceability: Europa (JEO focus)

EUROPA				
Goal	Science objective		Science investigation	
Explore Europa to investigate its habitability.	EA. Ocean	Characterize the extent of the ocean and its relation to the deeper interior.	EA.1	Determine the amplitude and phase of the gravitational tides.
			EA.2	Determine the magnetic induction response from the ocean and characterize the influence of space plasma environment on this response.
			EA.3	Characterize surface motion over the tidal cycle.
			EA.4	Determine the satellite's dynamical rotation state (forced libration, obliquity and nutation).
			EA.5	Investigate the core, rocky mantle, rock-ocean interface, and compensation of the ice shell.
	EB. Ice	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange.	EB.1	Characterize the distribution of any shallow subsurface water and the structure of the icy shell including its subsurface properties.
			EB.2	Search for an ice-ocean interface.
			EB.3	Correlate surface features and subsurface structure to investigate processes governing material exchange among the surface, ice shell, and ocean.
			EB.4	Characterize regional and global heat flow variations.
	EC. Composition	Determine global composition, distribution and evolution of surface materials, especially as related to habitability.	EC.1	Characterize surface organic and inorganic chemistry, including abundances and distributions of materials, with emphasis on indicators of habitability and potential biosignatures and measure volatile content to understand the origin and evolution.
			EC.2	Relate material composition and distribution to geological processes, especially material exchange with the interior.
			EC.3	Investigate the effects of radiation on surface composition, including organics, and regional structure.
			EC.4	Characterize the nature of exogenic (*e.g.* Io) materials.
	ED. Geology	Understand the formation of surface features, including sites of recent or current activity, and identify and characterize candidate sites for potential future *in situ* exploration.	ED.1	Determine the formation and three-dimensional characteristics of magmatic, tectonic, and impact landforms.
			ED.2	Determine sites of most recent geological activity, and evaluate future potential landing sites.
			ED.3	Constrain global and regional surface ages.
			ED.4	Investigate processes of erosion and deposition and their effects on the physical properties of the surface.
	EE. Local Environment	Characterize the local environment and its interaction with the jovian magnetosphere	EE.1	Characterize the composition, structure, dynamics and variability of the bound and escaping neutral atmosphere, ionosphere, and local (within the Hill sphere) charged particle population.

Europa Traceability Detail

	Objective	Investigation	Example Measurements	Instrument
EC. Composition	C. Determine global composition, distribution and evolution of surface materials, especially as related to habitability.	EC1. Characterize surface organic and inorganic chemistry, including abundances and distributions of materials, with emphasis on indicators of habitability.	C1a. Surface reflectance measurements at better than or equal to 25-m/pixel spatial resolution, with better than 5-nm (10-nm minimum) spectral resolution through a spectral range of 0.4- to 2.5-microns (1- to 2.5-microns minimum), and better than 10-nm spectral resolution (20-nm minimum) through a spectral range of at least 2.5- to 5-microns, along profiles with less than or equal to 25-km spacing over more than 80% of the surface, plus targeted characterization of selected sites. SNR better than 128 for 0.9- to 2.6-microns and better than 32 for 2.6- to 5-microns.	C1a. Vis-IR imaging spectrometer
			C1b. Characterize the composition of sputtered products from energetic particle bombardment of the surface, as appropriate to organic and inorganic species as astrobiological indicators, over a mass range equal to or greater than 300 Daltons, mass resolution better than 500, and sensitivity that allows measurement of partial pressures as low as 10^{-17} mbar.	C1b. Ion and neutral mass spectrometer
			C1c. Surface reflectance measurements at better than or equal to 100-m/pixel spatial resolution, and better than or equal 3-nm spectral resolution, through a spectral range of at least 0.1- to 0.35-microns, using profiles at less than or equal to 25-km spacing over more than 80% of the surface, plus targeted characterization of selected sites.	C1c. UV imaging spectrometer
		EC2. Relate material composition and distribution to geological processes, especially material exchange with the interior.	C2a. Surface reflectance measurements of targeted features at better than or equal to 25-m/pixel spatial resolution, with better than 5-nm (10-nm minimum) spectral resolution through a spectral range of at least 0.4- to 2.5-microns (1- to 2.5-microns minimum), and better than 10-nm (20-nm minimum) through a spectral range of at least 2.5- to 5-microns. SNR better than 128 for 0.9- to 2.6-microns and better than 32 for 2.6- to 5-microns.	C2a. Vis-IR imaging spectrometer
			C2b. Global identification and local characterizaton of physical and dielectric subsurface horizons, at depths 1- to 30-km at 100-m vertical resolution and depths of 100-m to 3-km at 10-m vertical resolution, by obtaining subsurface profiles with better than 50-km spacing, plus targeted characterization of selected sites.	C2b. Radar sounder
			C2c. Surface reflectance measurements of targeted features at better than or equal to 100-m/pixel spatial resolution, and better than or equal 3-nm spectral resolution, through a spectral range of at least 0.1- to 0.35-microns.	C2c. UV imaging spectrometer
			C2d. High-resolution topography of targeted features, at better than or equal 10-m/pixel.	C2d. Medium-or Narrow-angle camera (stereo)
			C2e. Map thermal emission from the surface by measuring albedo to 10% radiometric accuracy at better than or equal to 250-m/pixel spatial resolution, and by making thermal observations at spatial resolution better than or equal to 250-m/pixel spatial resolution and temperature accuracy better than 2 K, over more than 80% of the surface.	C2e. Thermal imager
			C2f. Detailed morphological characterization of targeted features at better than or equal to 1-m/pixel spatial scale.	C2f. Narrow-angle camera
			C2g. Topography on the order of 100-m/pixel spatial scale and better than or equal to 10-m vertical resolution over >80% of the surface, and topographic characterization at better than 10-m/pixel spatial scale and better than or equal to 1-m vertical resolution and accuracy for targeted features, co-located with subsurface profiles.	C2g. Wide-, Medium- or Narrow-angle camera (stereo), and laser altimeter

Note: Example is from 2008 JEO Study

JEO Model Payload

Ocean	
Laser Altimeter	LA
Radio Science	RS
Ice	
Ice Penetrating Radar	IPR
Chemistry	
Vis-IR Imaging Spectrometer	VIRIS
UV Spectrometer	UVS
Ion and Neutral Mass Spectrometer	INMS
Geology	
Thermal Instrument*	TI
Narrow Angle Camera	NAC
Wide Angle Camera and Medium Angle Camera	WAC + MAC
Fields and Particles	
Magnetometer	MAG
Particle and Plasma Instrument	PPI

* No analogous instrument in JGO model payload

- Model payload is a proof-of-concept example
  - Other instrument choices may be viable
- Emphasizes accomplishing Europa investigations
- Enables robust Jupiter system science
- The final selected payload would probably be different

Capable model payload with a conservative approach

Links Between Investigations and Instruments: *Europa Science Example*

Objective		Science Investigation	RS	LA	IPR	VIRIS	UVS	INMS	WAC +MAC	NAC	TI	MAG	PPI
A. OCEAN: Characterize the extent of the ocean and its relationship to the deeper interior.	A1.	Determine the amplitude and phase of the gravitational tides.	P	S									
	A2.	Characterize the magnetic environment (including plasma), to determine the induction response from the ocean, over multiple frequencies.										P	S
	A3.	Characterize surface motion over the tidal cycle.	S	P									
	A4.	Determine the satellite's dynamical rotation state.	P	S									
	A5.	Investigate the core, rocky mantle, and rock-ocean interface.	P	P								S	S
B. ICE: Characterize the ice shell and any subsurface water, including heterogeneity, and the nature of surface-ice-ocean exchange.	B1.	Characterize the distribution of any shallow subsurface water.		S	P				S				
	B2.	Search for an ice-ocean interface.		S	P				S				
	B3.	Correlate surface features and subsurface structure to investigate processes governing material exchange among the surface, ice shell, and ocean.	S	P	P	P	S		P	S	P		
	B4.	Characterize regional and global heat flow variations.			P						S		
C. CHEMISTRY: Determine global surface compositions and chemistry, especially as related to habitability.	C1.	Characterize surface organic and inorganic chemistry, including abundances and distributions of materials, with emphasis on indicators of habitability and potential biosignatures.				P	S	P					
	C2.	Relate compositions to geological processes, especially material exchange with the interior.		S	P	P	P		P	S	S		
	C3.	Characterize the global radiation environment and the effects of radiation on surface composition, atmospheric composition, albedo, sputtering, sublimation, and redox chemistry.				P	P	P		S	S		S
	C4.	Characterize the nature of exogenic materials.				P	S	P	S				P
D. GEOLOGY: Understand the formation of surface features, including sites of recent or current activity, and identify and characterize candidate sites for future *in situ* exploration.	D1.	Determine the formation history and three-dimenstional characteristics of magmatic, tectonic, and impact landforms.		P	P	S	S		P	S	S		
	D2.	Determine sites of most recent geological activity, and evaluate future landing sites.				S	P		P	S	P		S
	D3.	Investigate processes of erosion and deposition and their effects on the physical properties of the surface debris.				S				P	P	S	S

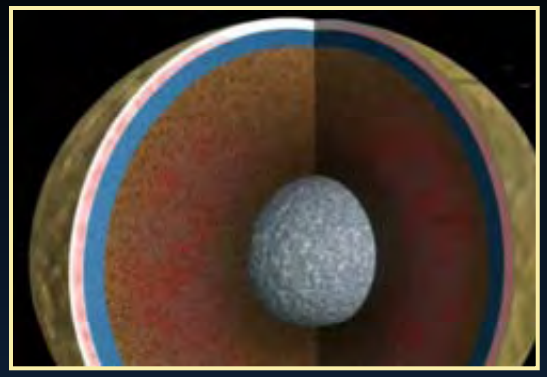
Primary

Secondary

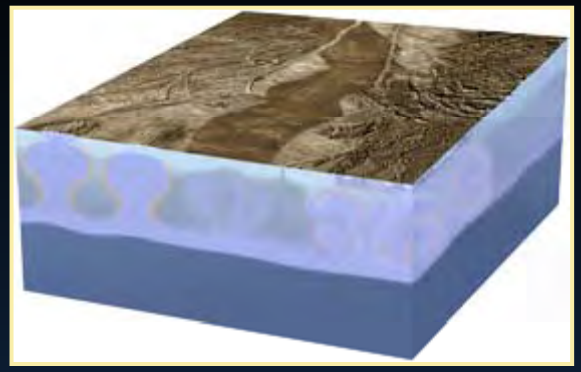
Multiple instruments would work together to address investigations

Note: Example is from 2008 JEO Study

Europa Objectives:
Ocean • Ice • Composition • Geology • Local



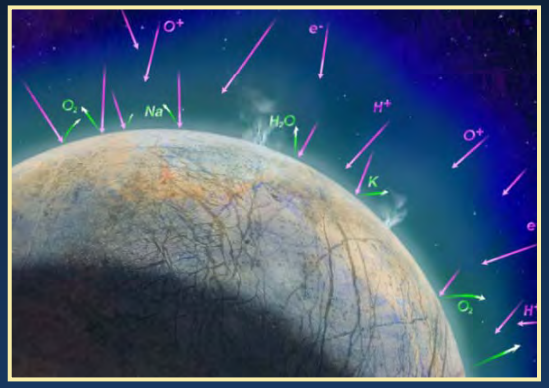
Ocean



Ice

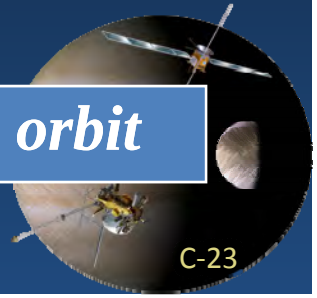
Composition

Geology



Local environment

JEO would address fundamental Europa science from orbit

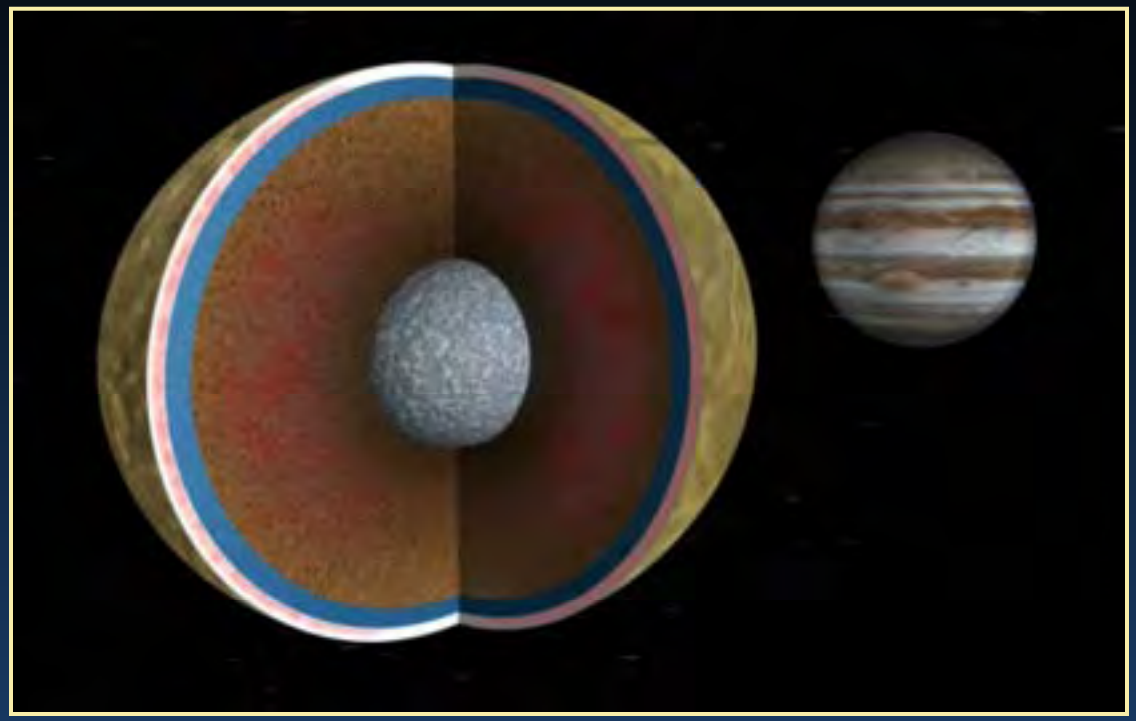


Europa Objectives:

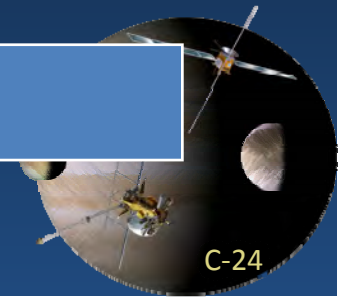
Ocean • Ice • Composition • Geology • Local

Ocean & deeper interior:

- Gravitational tides
- Induced magnetic field
- Surface motion
- Dynamical rotation state
- Core, rocky mantle, rock-ocean interface, & ice compensation



Geophysical techniques reveal the interior



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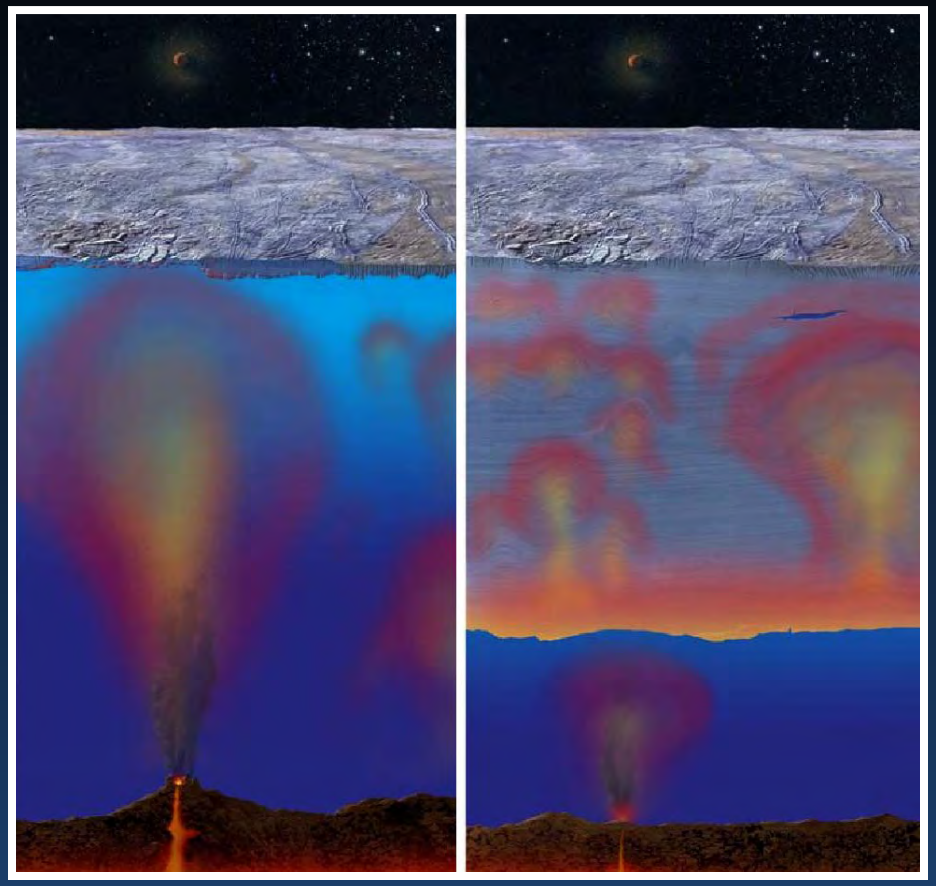
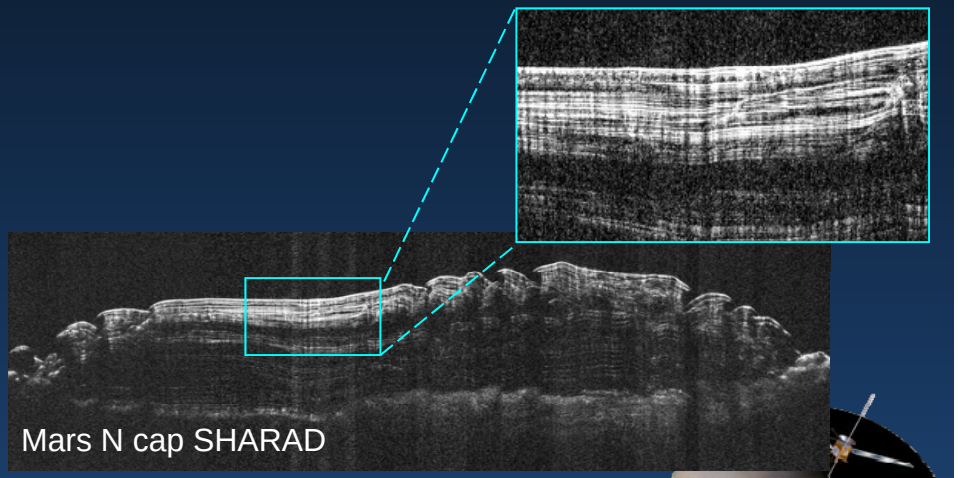


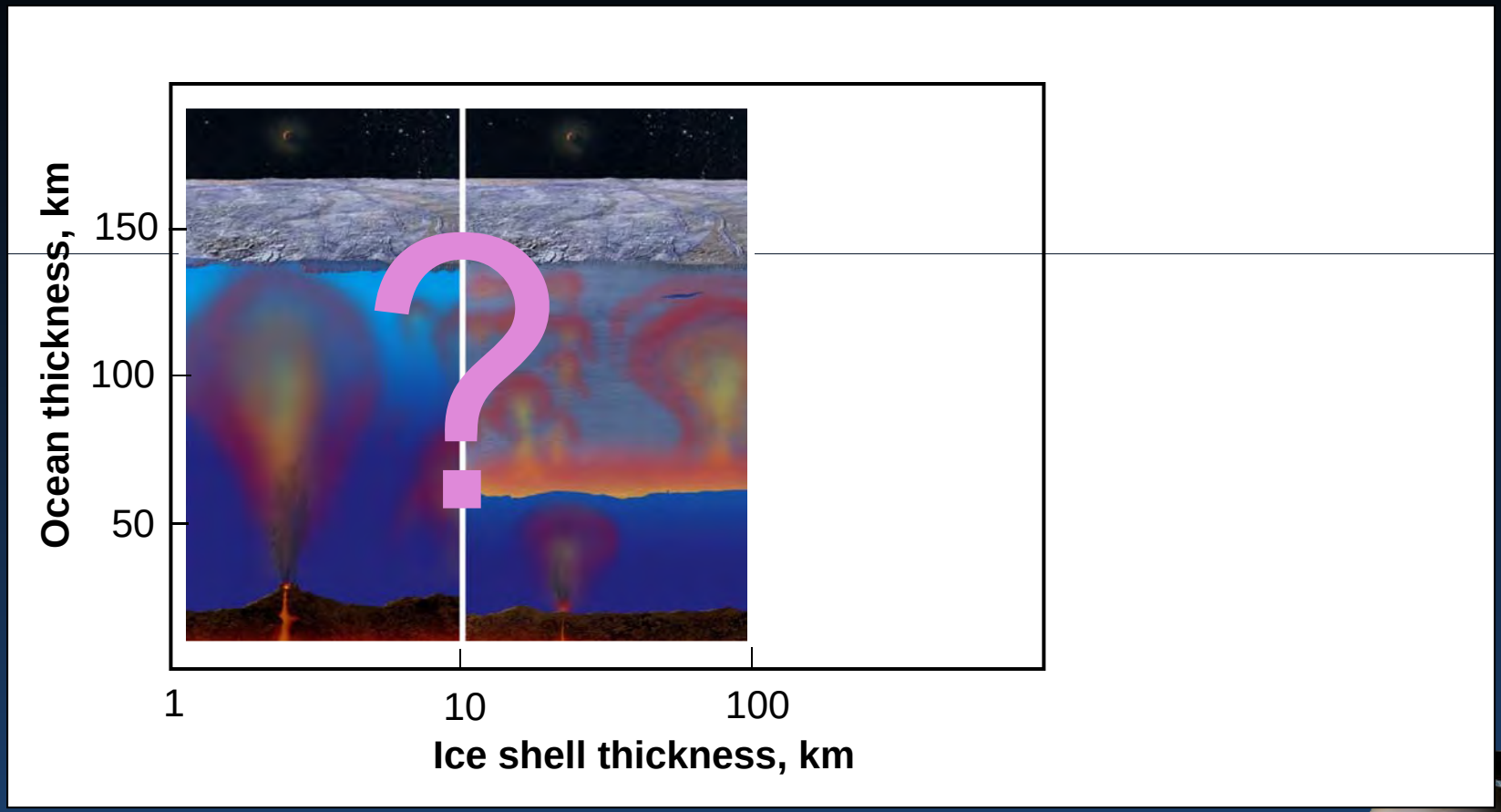
Ice shell & subsurface water:

- Shallow water
- Ice-ocean interface
- Material exchange
- Heat flow variations

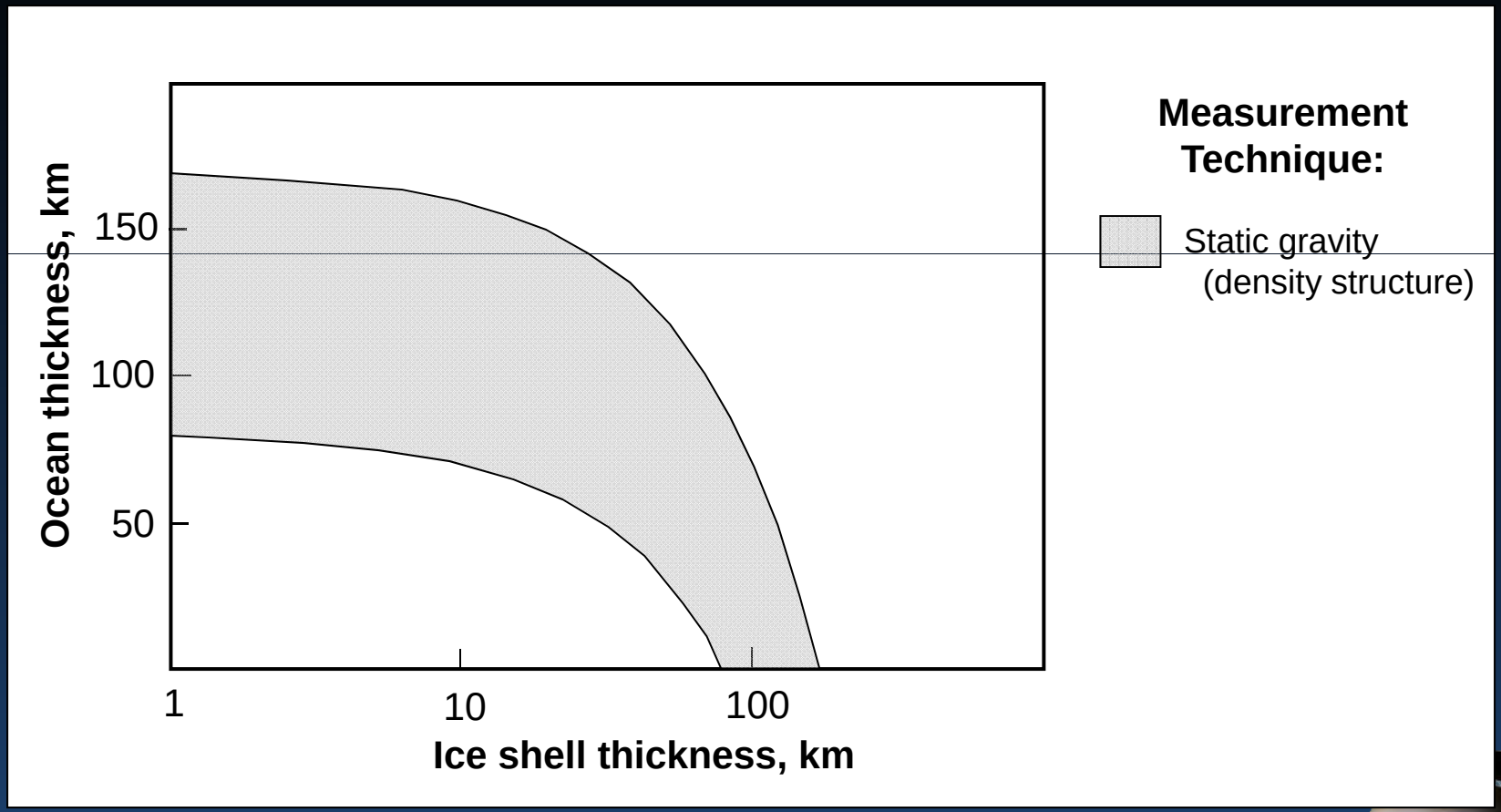


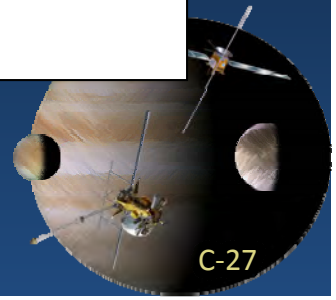
Sounding profiles would characterize the ice shell in 3 dimensions

Constraining Ice Shell Thickness: *Hypothetical Example*

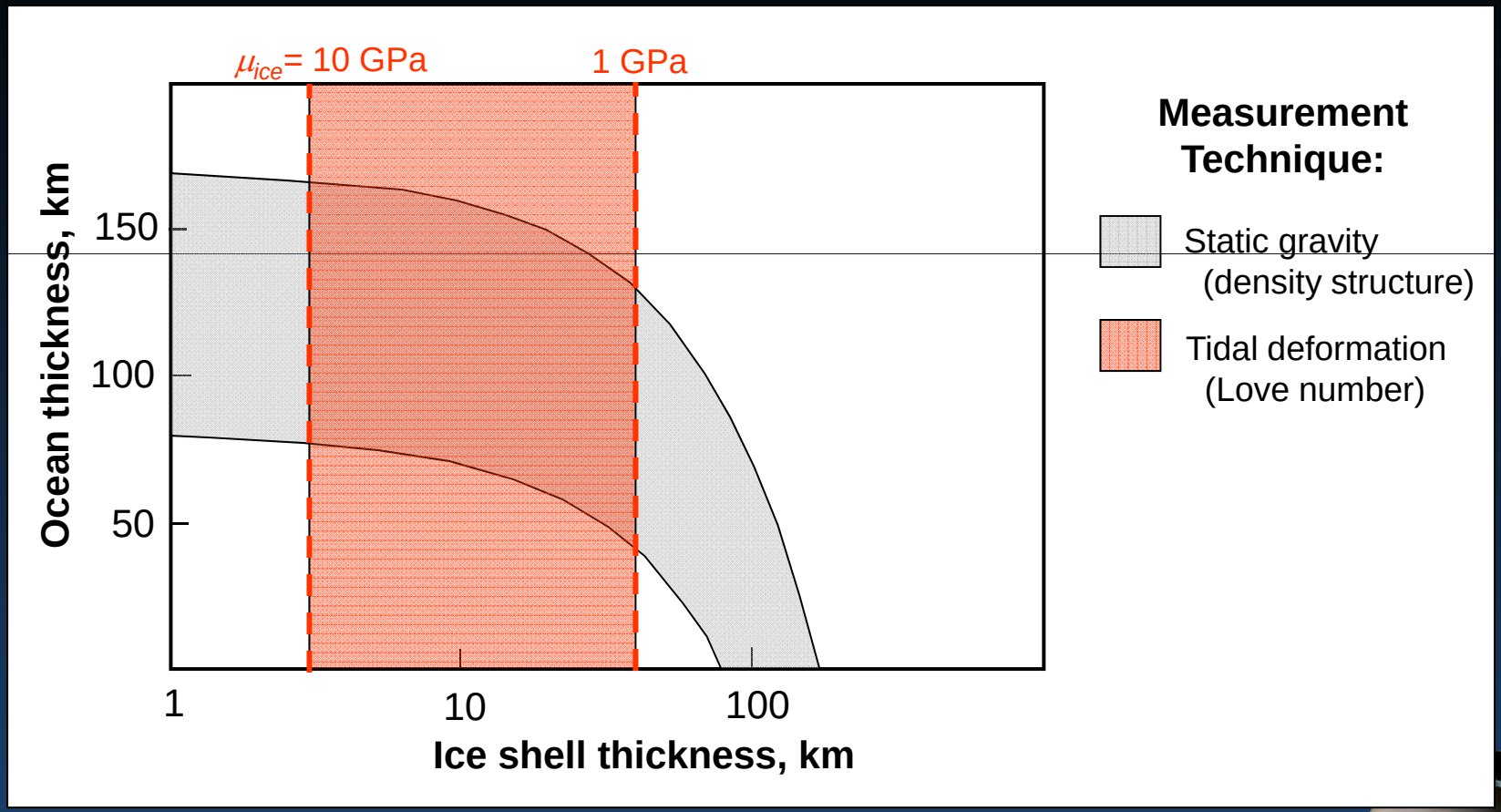


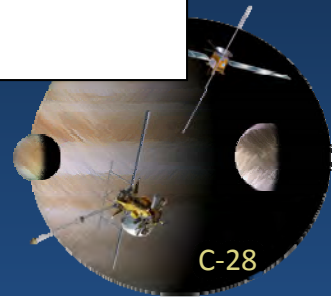
Constraining Ice Shell Thickness: *Hypothetical Example*



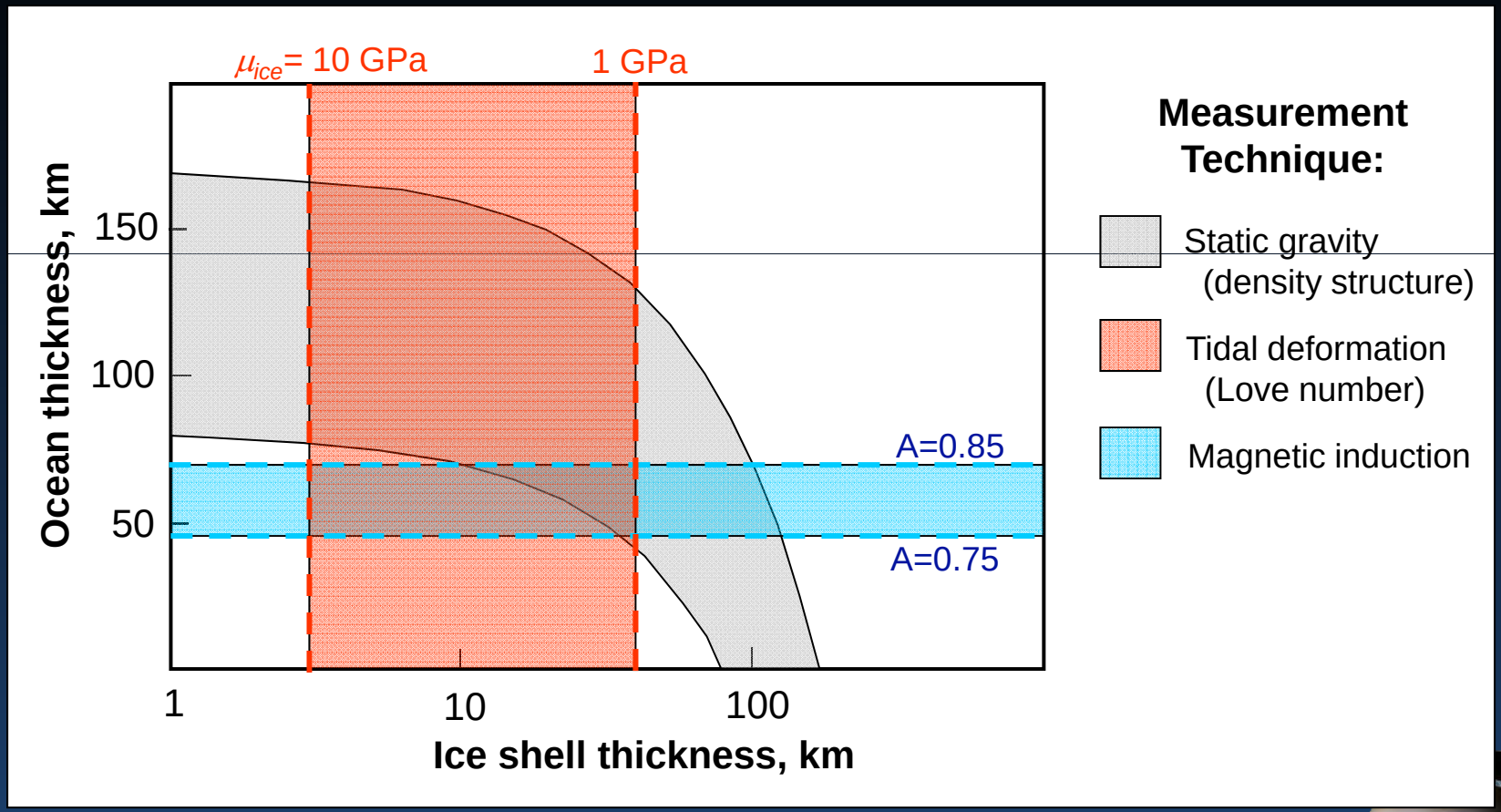


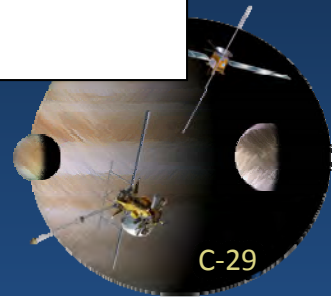
Constraining Ice Shell Thickness: *Hypothetical Example*



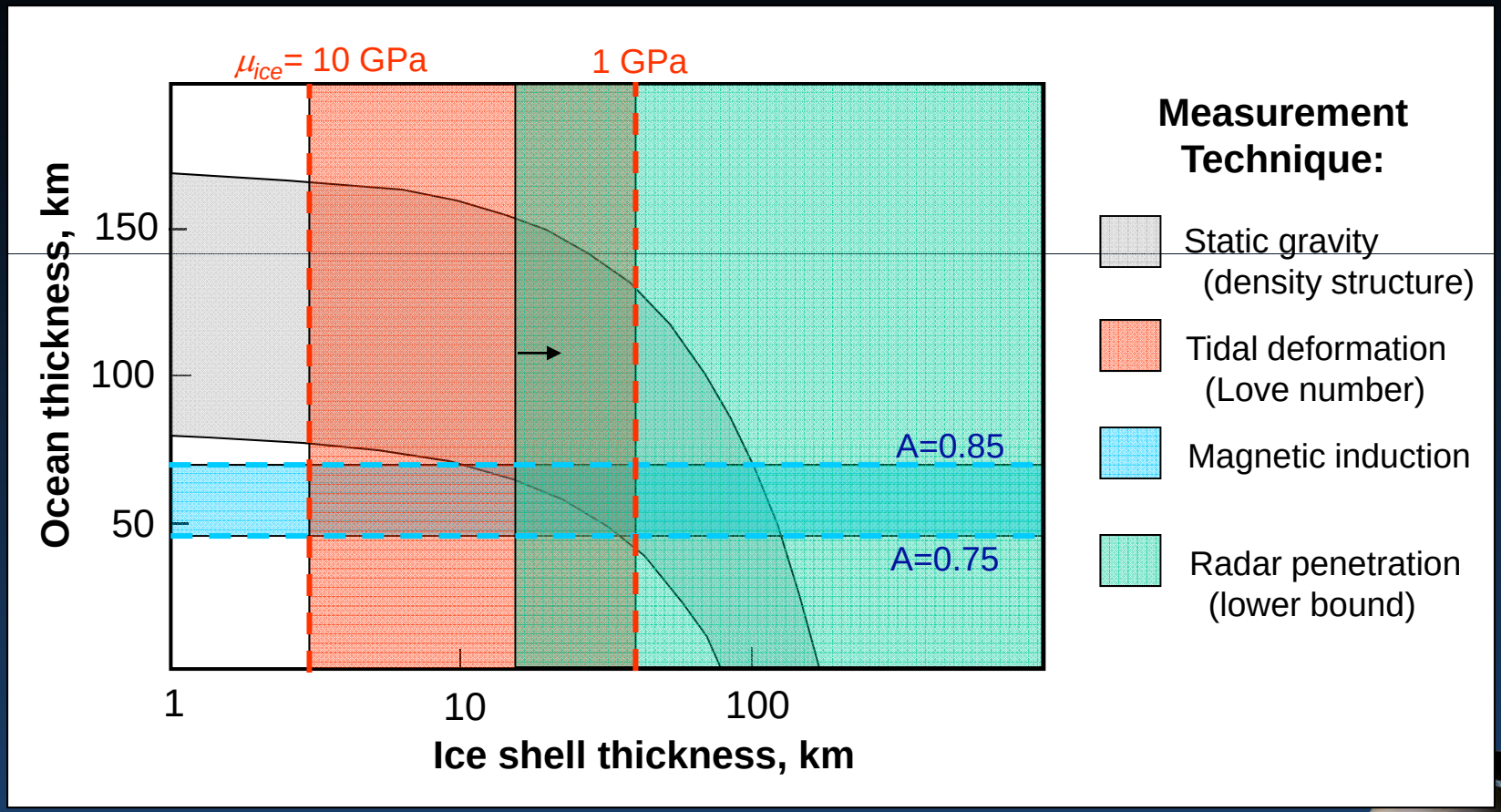


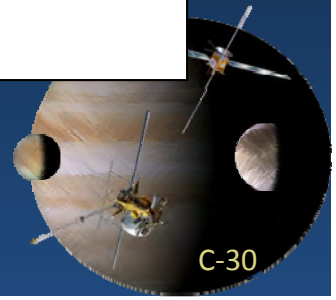
Constraining Ice Shell Thickness: *Hypothetical Example*



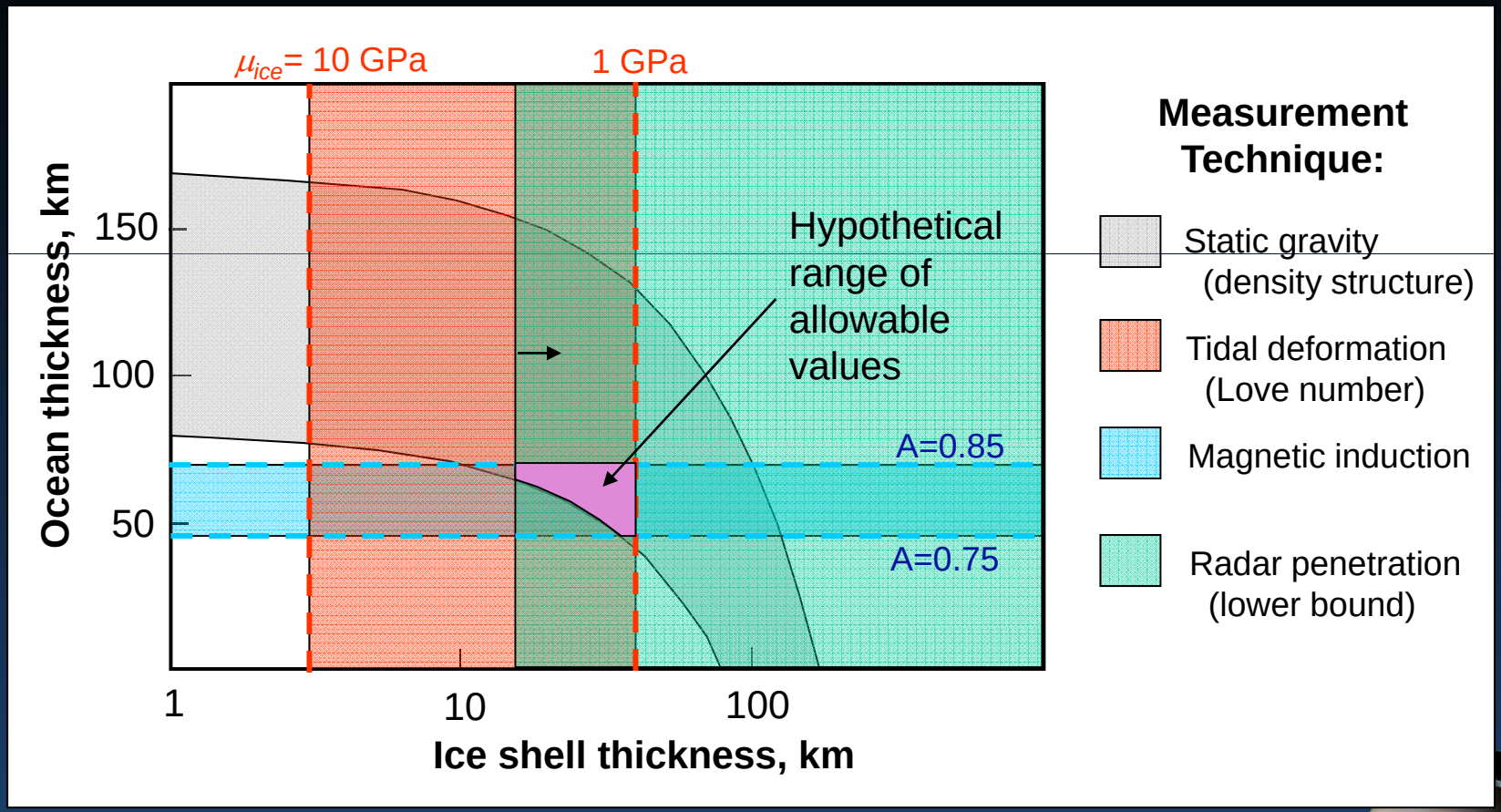


Constraining Ice Shell Thickness: *Hypothetical Example*





Constraining Ice Shell Thickness: *Hypothetical Example*



Multiple techniques constrain ice shell thickness

Europa Objectives:
Ocean • Ice • Composition • Geology • Local

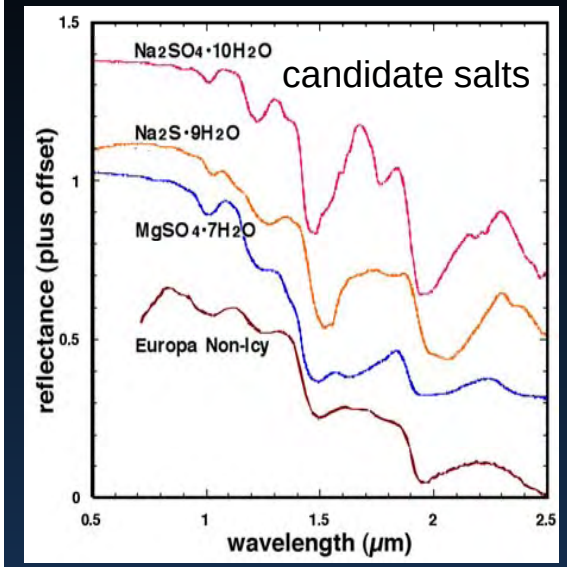
Global surface composition:

- Organic & inorganic chemistry, and volatile content
- Relation to geological processes
- Radiation effects
- Exogenic materials

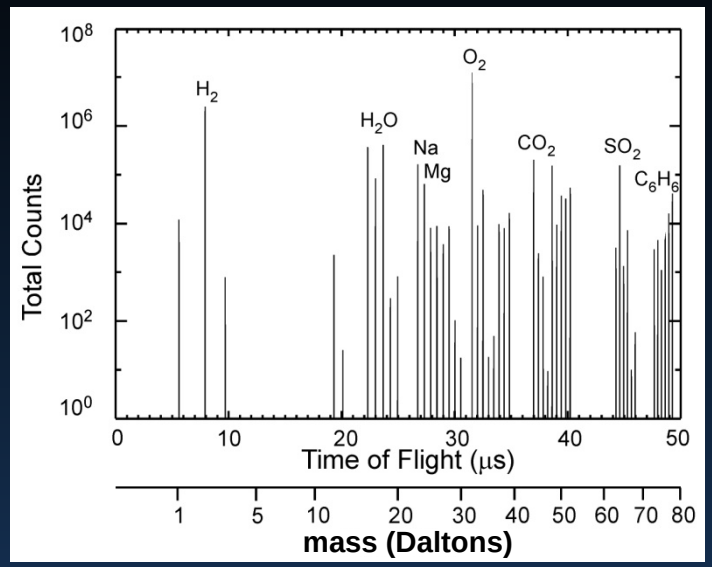
Composition is key to understanding ocean habitability

Europa Objectives:

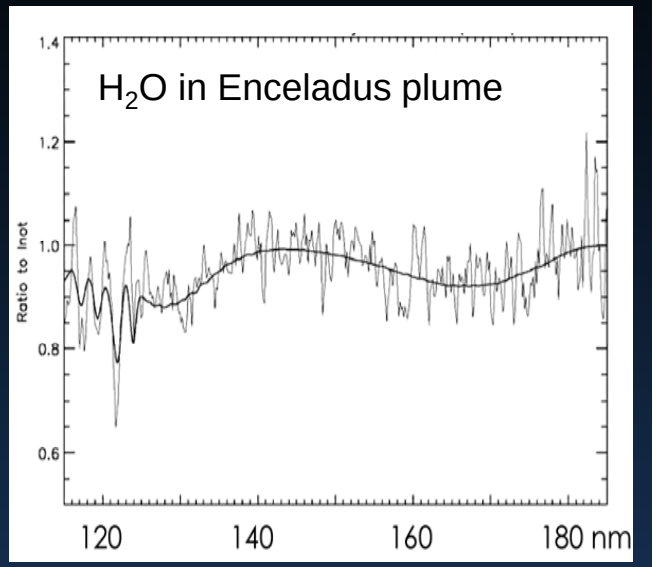
Ocean • Ice • Composition • Geology • Local



IR spectroscopy:
surface constituents



INMS:
sputtered particles



Stellar occultations:
atmospheric species

Multiple techniques can characterize and map composition

Europa Objectives:

Ocean • Ice • Composition • Geology • Local

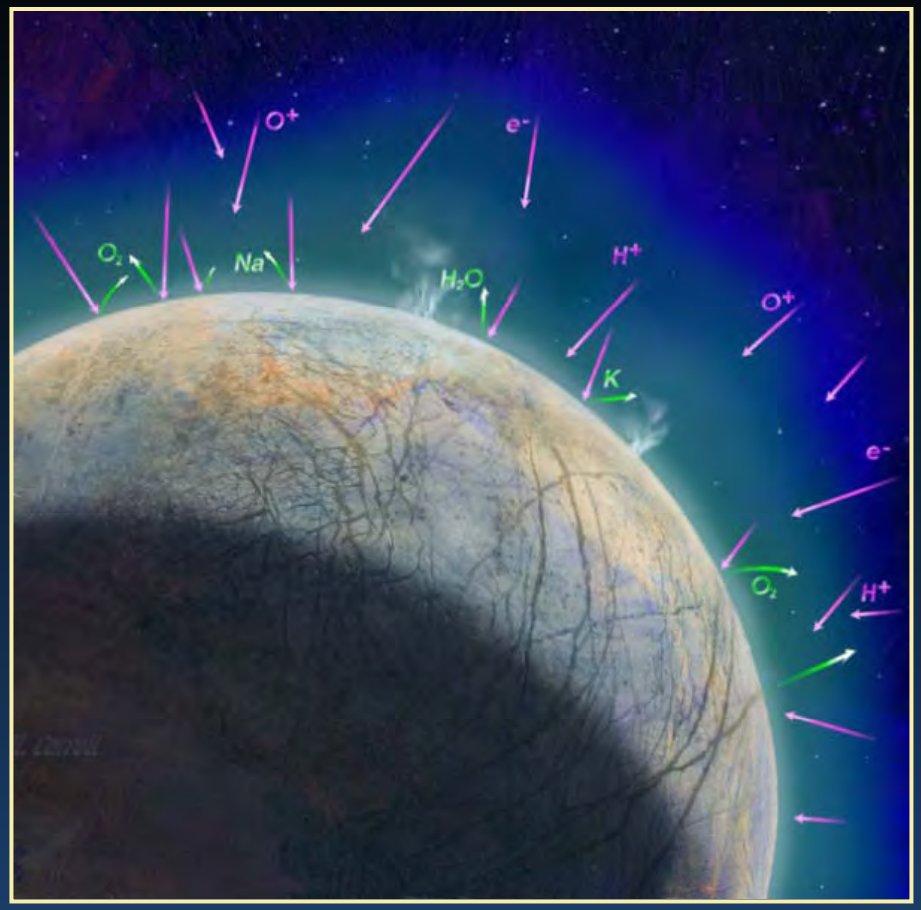
Surface features, activity, & landing sites:

- Formation & characteristics of landforms
- Recent activity & potential future landing sites
- Constrain surface ages
- Erosion & deposition

JEO would decipher Europa's varied and complex geology

Europa:

Ocean • Ice • Composition • Geology • Local



Local environment:

- Composition and dynamics of atmosphere and ionosphere
- Bound and escaping neutral atoms and molecules
- Charged particle population

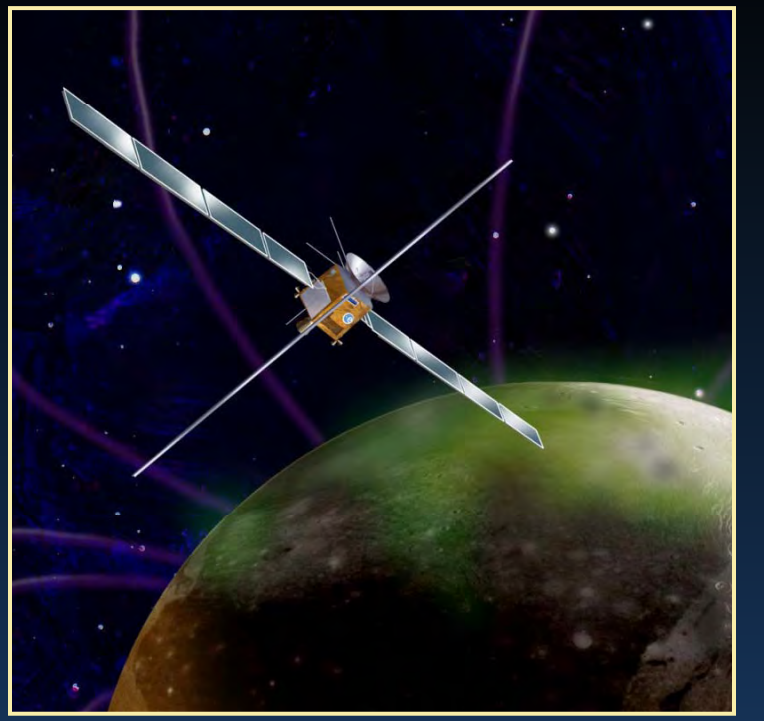
The local environment links the surface and the magnetosphere

EJSM Traceability: Ganymede (JGO focus)

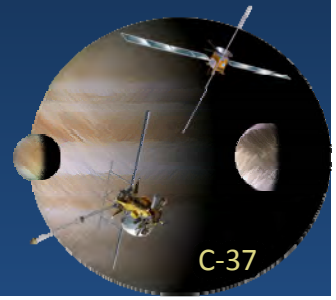
GANYMEDE				
Goal	Science objective		Science investigation	
Characterize Ganymede as a planetary object including its potential habitability	GA. Ocean	Characterize the extent of the ocean and its relation to the ice crust	GA.1	Determine the amplitude and phase of the gravitational tides.
			GA.2	Characterize the space plasma environment to determine the magnetic induction response from the ocean.
			GA.3	Characterize surface motion over the tidal cycle.
			GA.4	Determine the satellite's dynamical rotation state (forced libration, obliquity and nutation).
			GA.5	Investigate the core and rocky mantle.
	GB. Ice	Characterize the ice shell	GB.1	Characterize the structure of the icy shell including its properties and the distribution of any shallow subsurface water.
			GB.2	Correlate surface features and subsurface structure to investigate near-surface and interior processes.
	GC. Local Environment	Characterize the local environment and its interaction with the jovian magnetosphere	GC.1	Globally characterize Ganymede's intrinsic and induced magnetic fields, with implications for the deep interior.
			GC.2	Characterize particle population within Ganymede's magnetosphere and their interaction with Jupiter's magnetosphere.
			GC.3	Investigate the generation of Ganymede's aurora.
			GC.4	Determine the sources and sinks of the ionosphere and exosphere.
	GD. Geology	Understand the formation of surface features and search for past and present activity	GD.1	Determine the formation and characteristics of magmatic, tectonic, and impact landforms.
			GD.2	Constrain global and regional surface ages.
	GE. Composition	Determine global composition, distribution and evolution of surface materials	GE.1	Characterize surface organic and inorganic chemistry, including abundances and distributions of materials, and use volatile composition to understand origin and evolution.
			GE.2	Relate compositions and properties and their distributions to geology.
			GE.3	Investigate surface composition and structure on open vs. closed field line regions.

JGO Model Payload

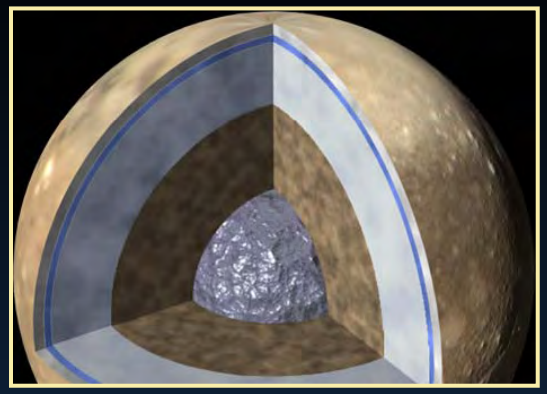
Model Instrument	Acronym
Medium-Res Camera & Wide Angle Camera	WAC+MRC
Magnetometer	MAG
Radio Science Transponder	JRST
Visible InfraRed Hyperspectral Imaging Spectrometer	VIRHIS
Plasma Package & Ion and Neutral Mass Spectrometer	PLP/INMS
Sub-mm Instrument*	SWI
Radio and Plasma Wave Instrument*	RPWI
Narrow Angle Camera	HRC
Sub-Surface Radar	SSR
Laser Altimeter	LA
UV Imaging Spectrometer	UVIS



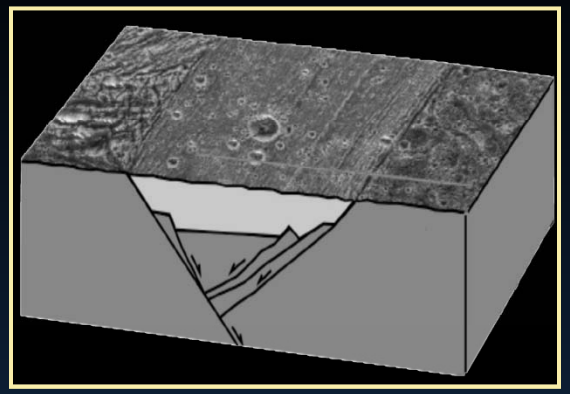
*No analogous instrument in JEO model payload



Ganymede Objectives:
Ocean • Ice • Local • Geology • Composition

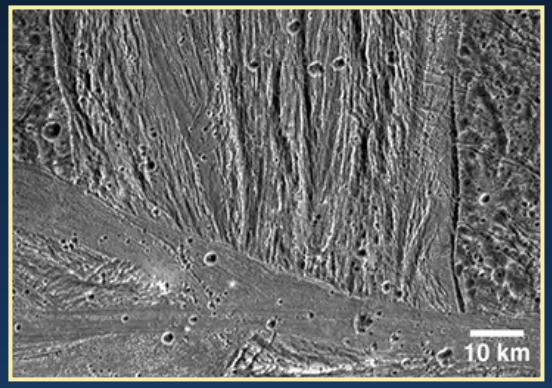


Ocean

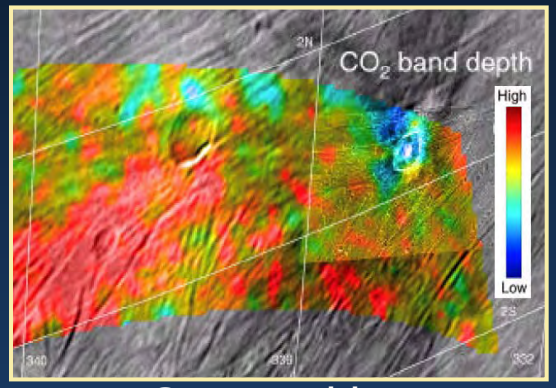


Ice

Local environment



Geology



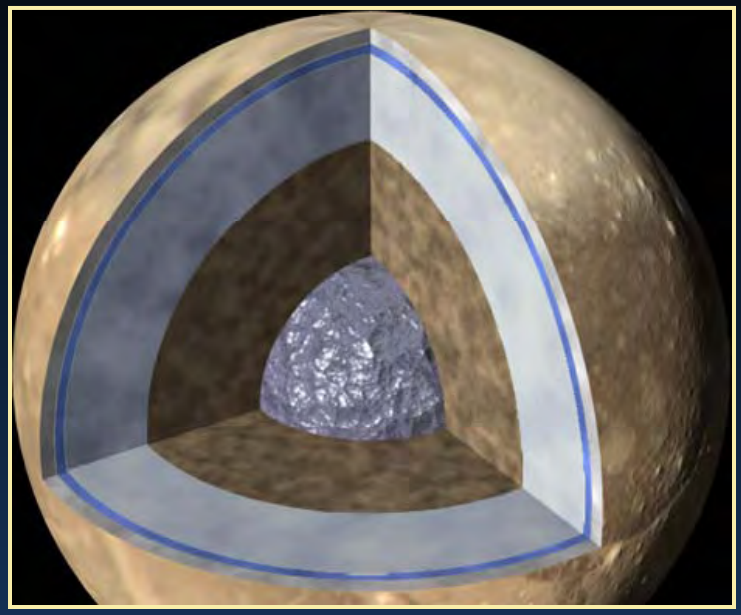
Composition

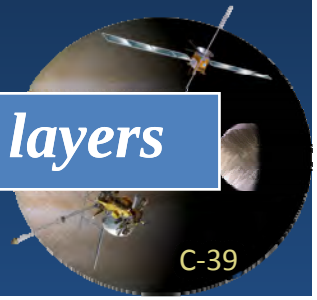
JGO would characterize Ganymede in detail from orbit

Ganymede Objectives:
Ocean • Ice • Local • Geology • Composition

Ocean & relation to ice:

- Gravitational tides
- Induced magnetic field
- Surface motion
- Dynamical rotation state
- Core & rocky mantle



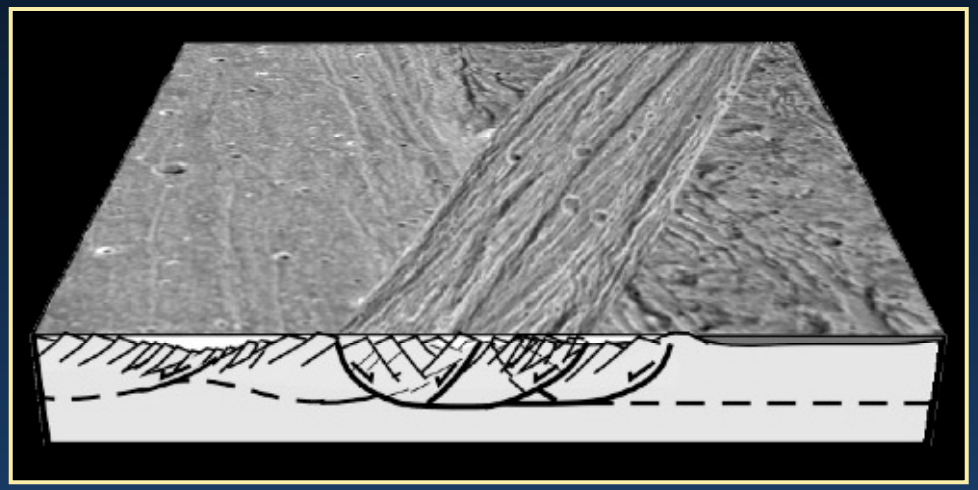


Ganymede's ocean is deep and sandwiched between ice layers

Ganymede Objectives:
Ocean • Ice • Local • Geology • Composition

Ice shell:

- Ice shell structure & shallow water
- Correlate surface & subsurface



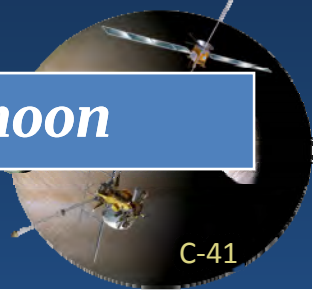
Multiple interrelated processes shaped the complex icy lithosphere

Ganymede Objectives:
Ocean • Ice • Local • Geology • Composition

Local environment:

- Intrinsic & induced fields, with implications for deep interior
- Particle population and interactions
- Generation of aurora
- Sources & sinks of ionosphere & exosphere

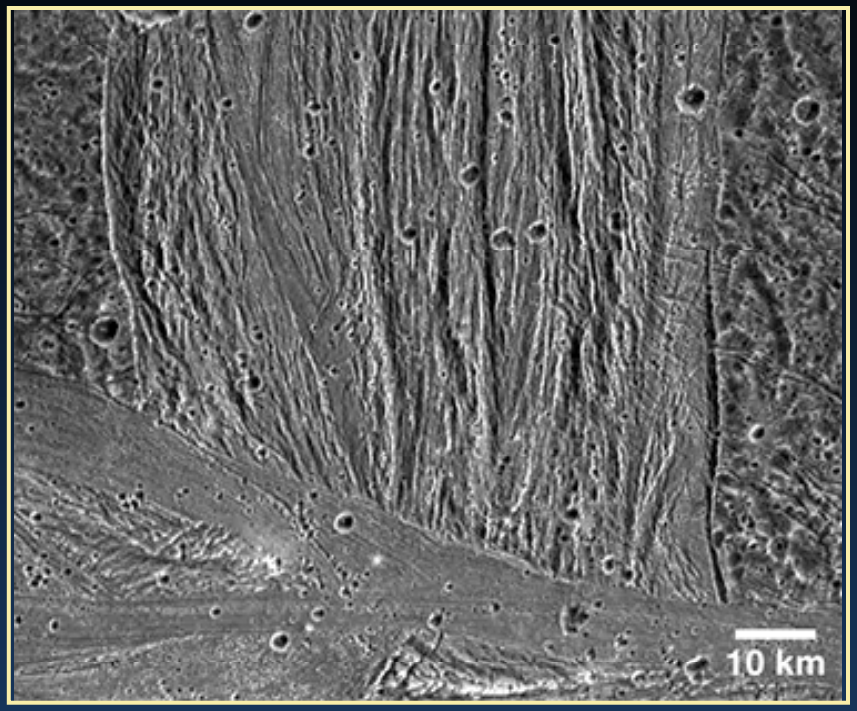
Ganymede's intrinsic magnetic field is unique for a moon



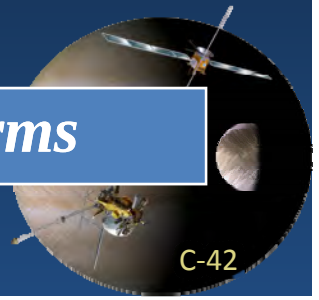
Ganymede Objectives:
Ocean • Ice • Local • Geology • Composition

Surface features & activity:

- Formation & characteristics of landforms
- Constrain surface ages



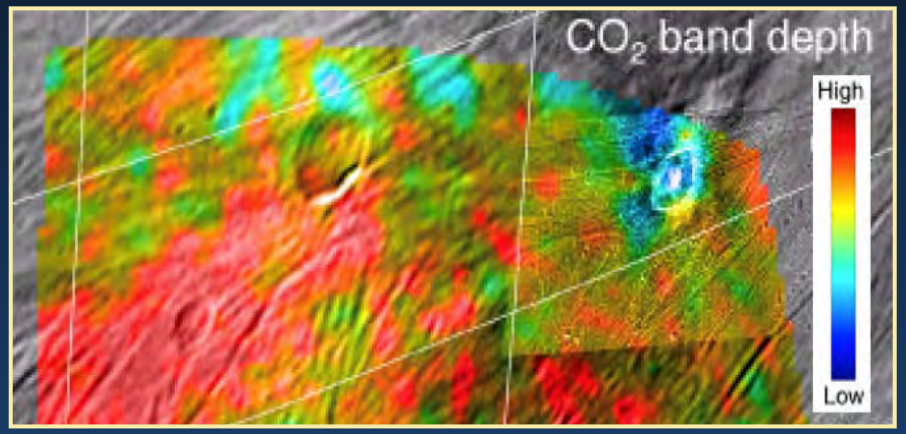
Ganymede shows a rich array of icy satellite landforms

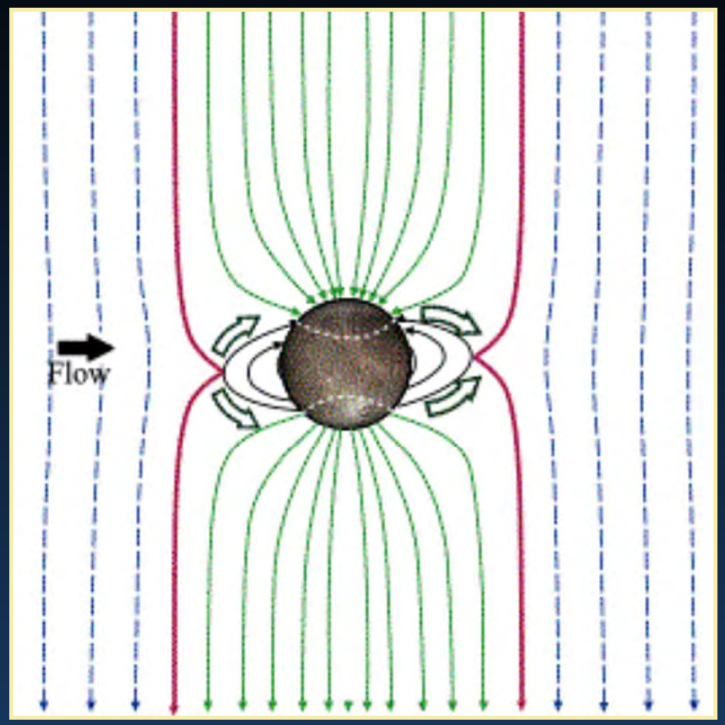


Ganymede Objectives:
Ocean • Ice • Local • Geology • Composition

Global surface composition:

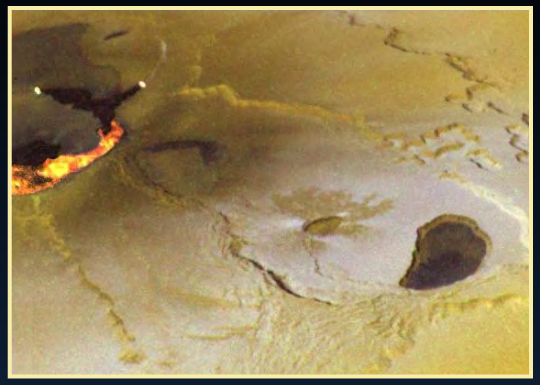
- Organic & inorganic chemistry, and volatile composition
- Relation to geological processes
- Open vs. closed field line regions



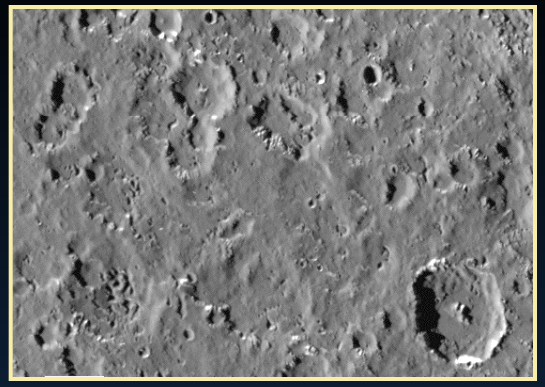


Composition is influenced by endogenic and exogenic processes

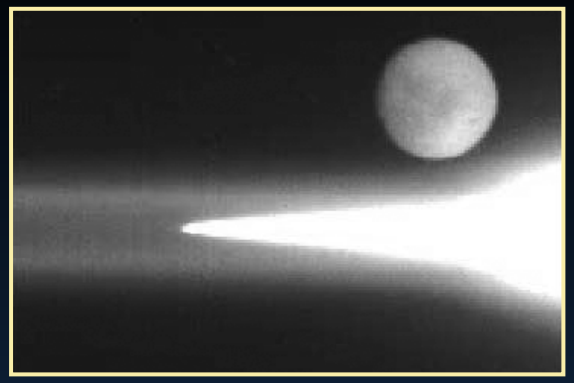
Jupiter System Objectives:
Io • Callisto • Rings • Jupiter • Magnetosphere



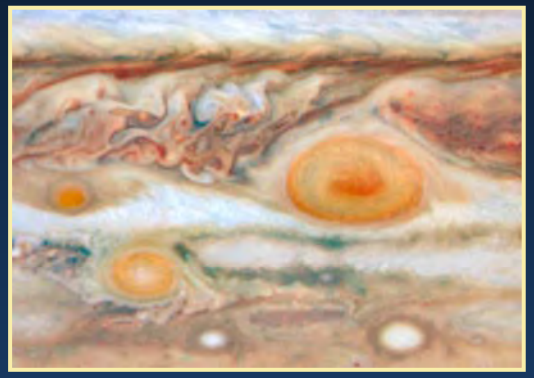
Io



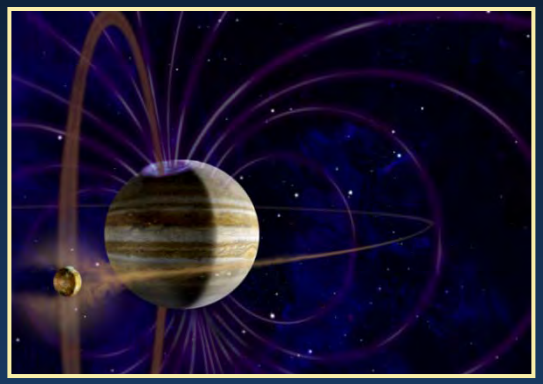
Callisto



Rings & small satellites

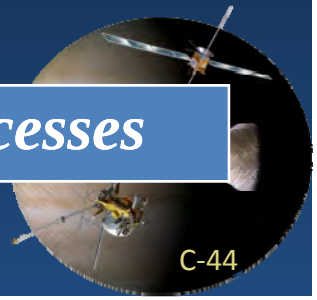


Jovian atmosphere



Jovian magnetosphere

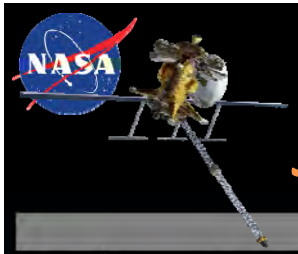
The Jupiter system is rich in dynamic and coupled processes

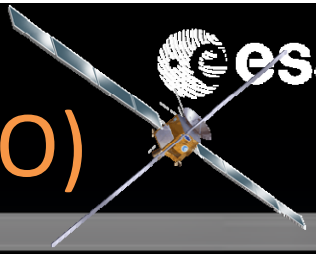


EJSM Traceability: Jupiter System Science (JEO + JGO)

JUPITER SYSTEM				
Goal	Science objective		Science investigation	
Explore the Jupiter system as an archetype for gas giants	SATELLITE SYSTEM			
	S. Study the Jovian satellite system	SA. Understand Io's active dynamic processes.	SA.1	Investigate the nature, distribution and magnitude, of tidal dissipation and heat loss on Io.
			SA.2	Investigate Io's composition and active volcanism for insight into its geological history and evolution (particularly of its silicate crust).
			SA.3	Determine the satellite's dynamical rotation state (forced libration, obliquity and nutation).
			SA.4	Investigate the interior of Io.
			SA.5	Understand satellite origin and evolution by assessing sources and sinks of Io's crustal volatiles and atmosphere.
		SB. Characterize Callisto as a witness of the early jovian system	SB.1	Constrain the tidally varying potential and shape of Callisto
			SB.2	Characterize the space plasma environment to determine the magnetic induction response from the ocean
			SB.3	Characterize the structure and properties of the icy shell.
			SB.4	Characterize surface organic and inorganic chemistry, including abundances and distributions of materials and volatile outgassing
			SB.5	Determine the satellite's dynamical rotation state (forced libration, obliquity and nutation).
			SB.6	Investigate the interior of Callisto.
			SB.7	Characterization of Callisto's ionosphere and exosphere
			SB.8	Relate material composition and distribution to geological and magnetospheric processes
			SB.9	Constrain global and regional surface ages
			SB.10	Determine the formation and characteristics of magmatic, tectonic, and impact landforms
	R. Rings and small Satellites	RA. Characterize the rings and small satellites	RA.1	Conduct a comprehensive survey of the components of the Jovian ring-moon system.
			RA.2	Identify the processes that define the origin and dynamics of the ring dust, source bodies, and small moons.
			RA.3	Characterize the physical properties of the inner small moons, ring source bodies and dust.
			RA.4	Remotely characterize the composition, properties and dynamical groupings of the outer irregular moons
			RA.5	Perform disk-resolved and local characterization of one or more outer, irregular moons

EJSM Traceability: Jupiter System Science (JEO + JGO)





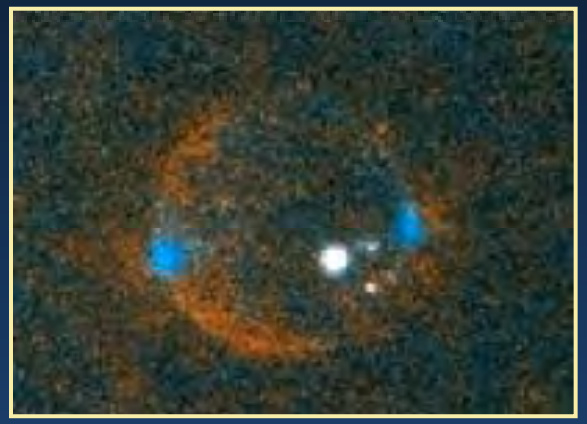
JUPITER SYSTEM				
Goal	Science objective		Science investigation	
Explore the Jupiter system as an archetype for gas giants	JUPITER			
	J. Jovian atmosphere	JA. Characterize the atmospheric dynamics and circulation	JA.1	Investigate the dynamics of Jupiter's weather layer.
			JA.2	Determine the thermodynamics of atmospheric phenomena.
			JA.3	Quantify the roles of wave propagation and atmospheric coupling.
			JA.4	Investigate auroral structure and energy transport.
			JA.5	Understand the interrelationships of the ionosphere and thermosphere.
		JB. Characterize the atmospheric composition and chemistry	JB.1	Determine Jupiter's bulk elemental abundances.
			JB.2	Measure the composition from the stratosphere to low thermosphere in three dimensions.
			JB.3	Study localized and non-equilibrium composition.
			JB.4	Understand the importance of moist convection in meteorology, cloud formation, and chemistry.
		JC. Characterize the atmospheric vertical structure	JC.1	Determine the three-dimensional structure from Jupiter's upper troposphere to lower thermosphere.
			JC.2	Explore Jupiter's interior density structure and dynamics below the upper troposphere.
			JC.3	Study coupling across atmospheric layers.
	MAGNETOSPHERE			
	M. Jovian magnetosphere	MA. Characterize the magnetosphere as a fast magnetic rotator	MA.1	Understand the structure and stress balance of Jupiter's magnetosphere.
			MA.2	Investigate the plasma processes, sources, sinks, composition and transport (including transport of magnetic flux) in the magnetosphere and characterize their variability in space and time.
			MA.3	Characterize the large-scale coupling processes between the magnetosphere, ionosphere and thermosphere, including moons footprints.
			MA.4	Characterize the magnetospheric response to solar wind variability and planetary rotation effects.
		MB. Characterize the magnetosphere as a giant accelerator	MB.1	Detail the particle acceleration processes.
			MB.2	Study the loss processes of charged energetic particles.
			MB.3	Measure the time evolving electron synchrotron emissions.
		MC. Understand the moons as sources and sinks of magnetospheric plasma	MC.1	Study the pickup and charge exchange processes in the Jupiter system plasma and neutral tori.
			MC.2	Study the interactions between Jupiter's magnetosphere and Io, Europa, Ganymede, and Callisto.
			MC.3	Study the interactions between Jupiter's magnetosphere and small satellites.

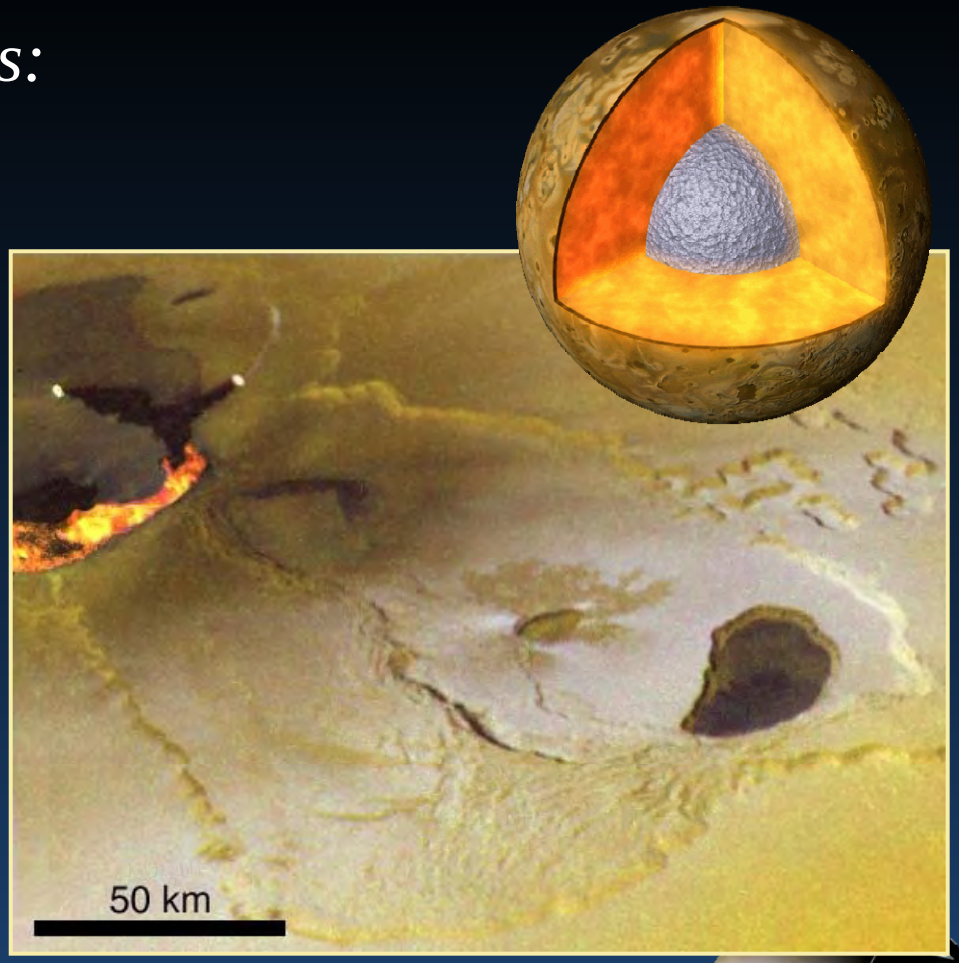
Jupiter System Objectives:

Io • Callisto • Rings • Jupiter • Magnetosphere

Io's active dynamic processes:

- Tidal heating & heat loss
- Composition, active volcanism, & geological history
- Dynamical rotation state
- Interior state
- Sources and sinks of volatiles & atmosphere





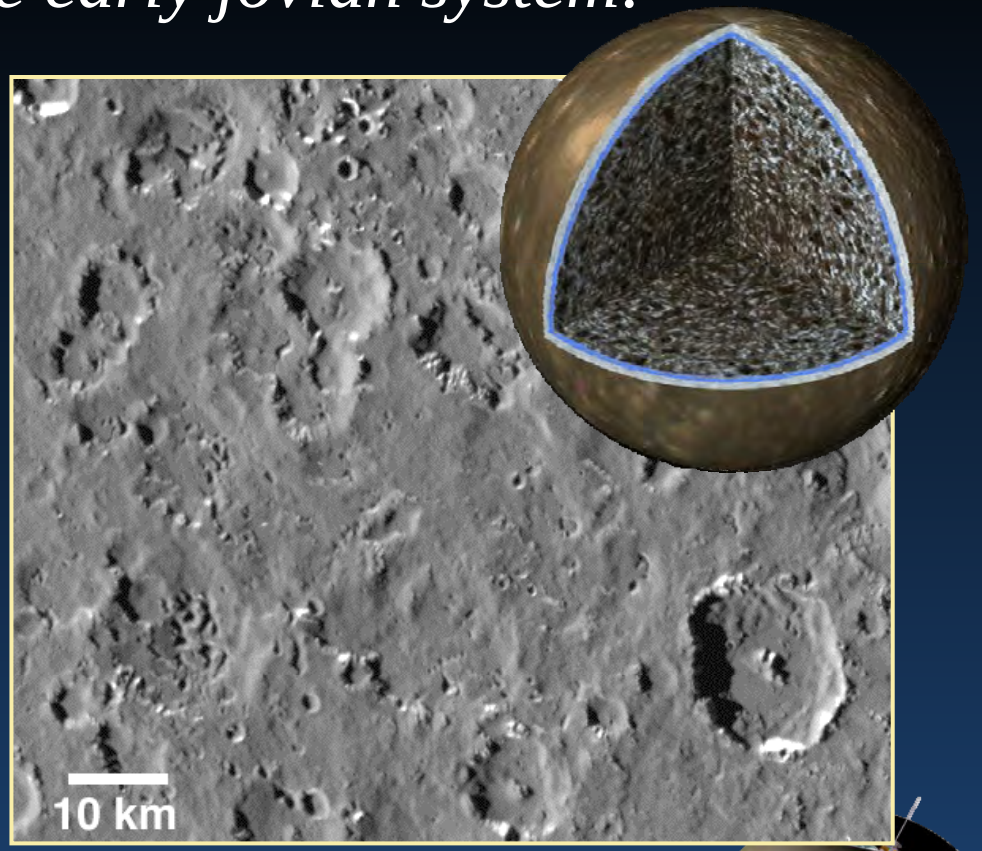
Io is the tidal engine of the Laplace resonance

Jupiter System Objectives:

Io • Callisto • Rings • Jupiter • Magnetosphere

Callisto as a witness of the early jovian system:

- Gravitational tides and shape
- Induced magnetic field
- Icy shell structure
- Surface and volatile chemistry
- Dynamical rotation state
- Interior structure
- Ionosphere & exosphere
- Relate composition to processes
- Constrain surface ages
- Geological processes



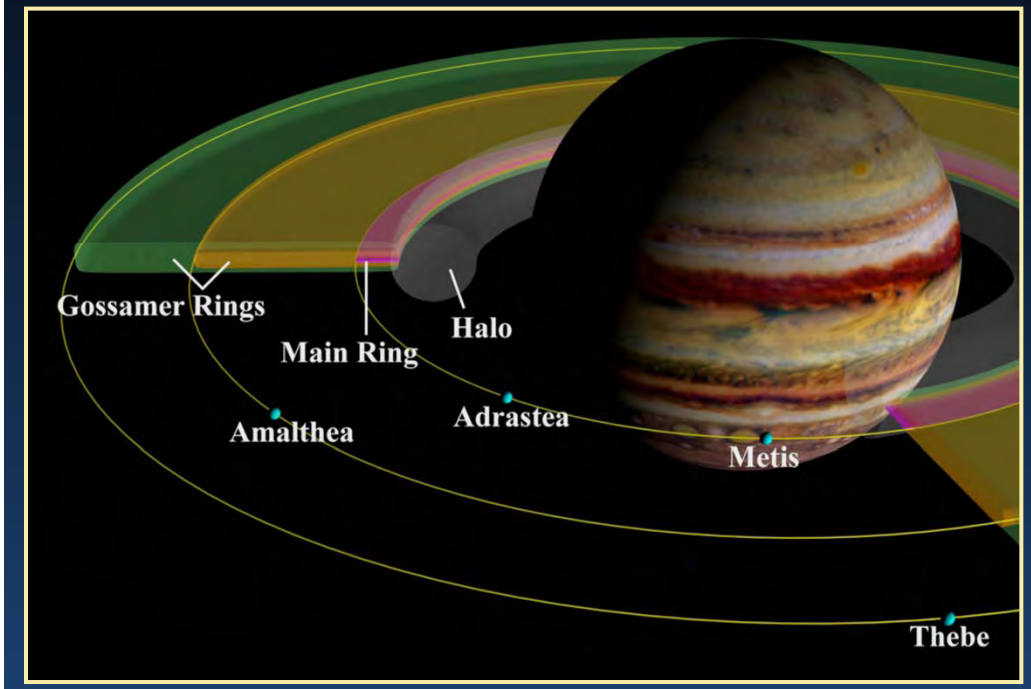
Callisto preserves a remarkably primitive surface and interior

Jupiter System Objectives:

Io • Callisto • Rings • Jupiter • Magnetosphere

Rings & small satellites:

- Survey the ring-moon system
- Dust dynamical processes
- Inner moon properties
- Outer moon properties
- Disk resolved irregular moon characterization (if feasible)



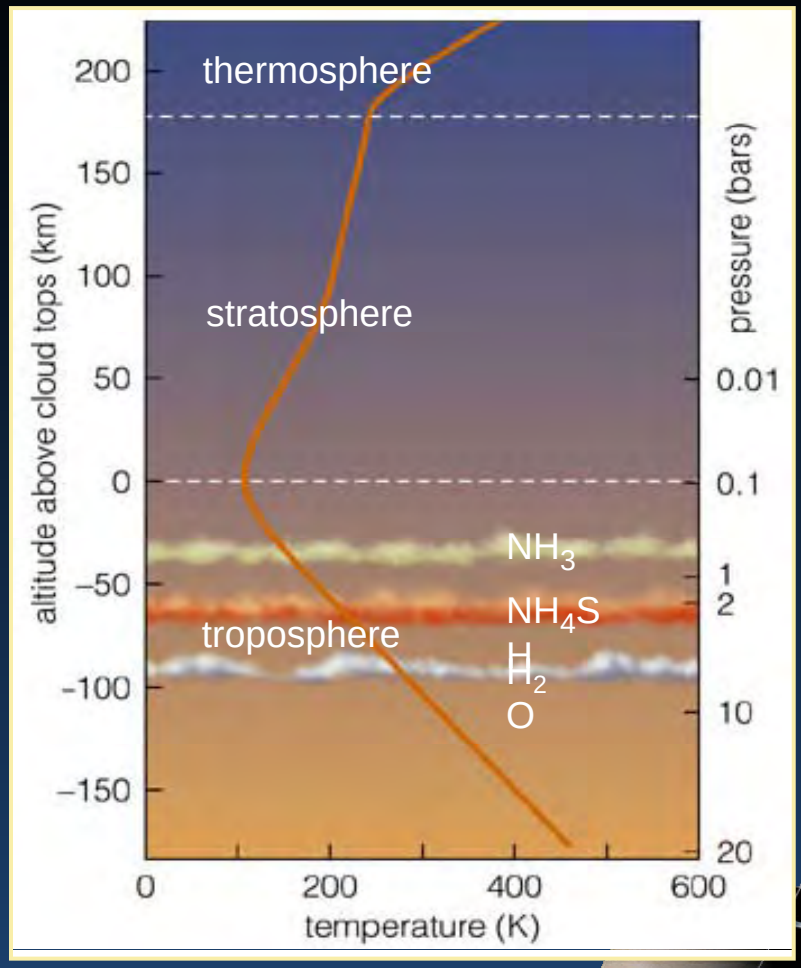
Ring, small satellite, & dust dynamics and evolution

Jupiter System Objectives:

Io • Callisto • Rings • Jupiter • Magnetosphere

Jovian atmosphere:

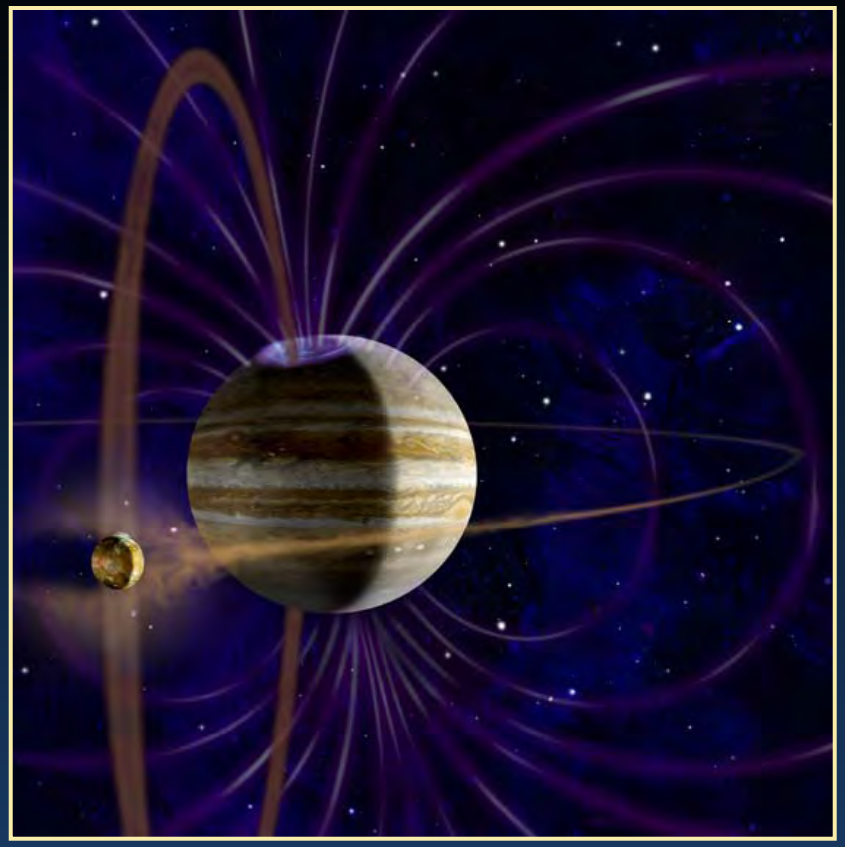
- Atmospheric dynamics & circulation
- Atmospheric composition & chemistry
- Atmospheric vertical structure



Addresses unanswered questions and complements Juno

Jupiter System Objectives:

Io • Callisto • Rings • Jupiter • Magnetosphere

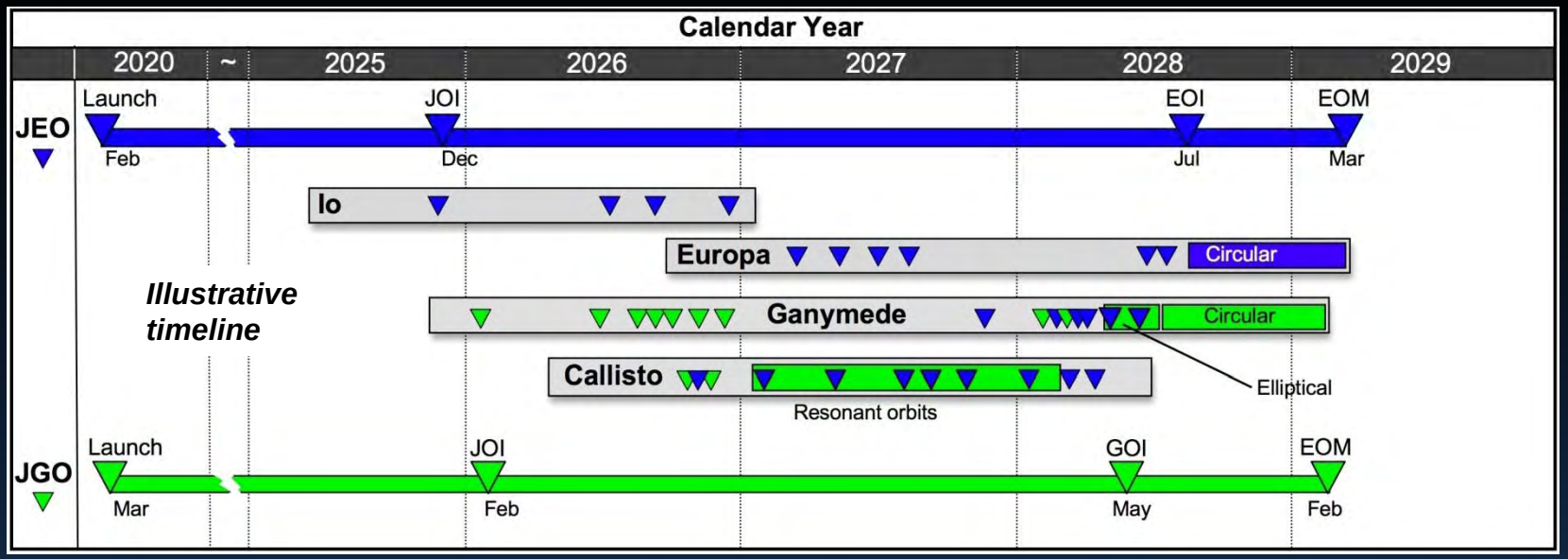


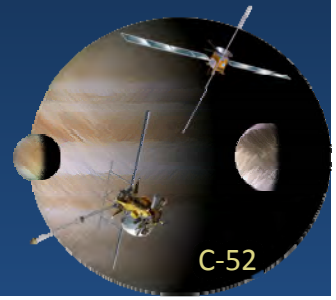
Jovian magnetosphere:

- Magnetosphere as a fast magnetic rotator
- Magnetosphere as a giant accelerator
- Moons as sources and sinks of plasma

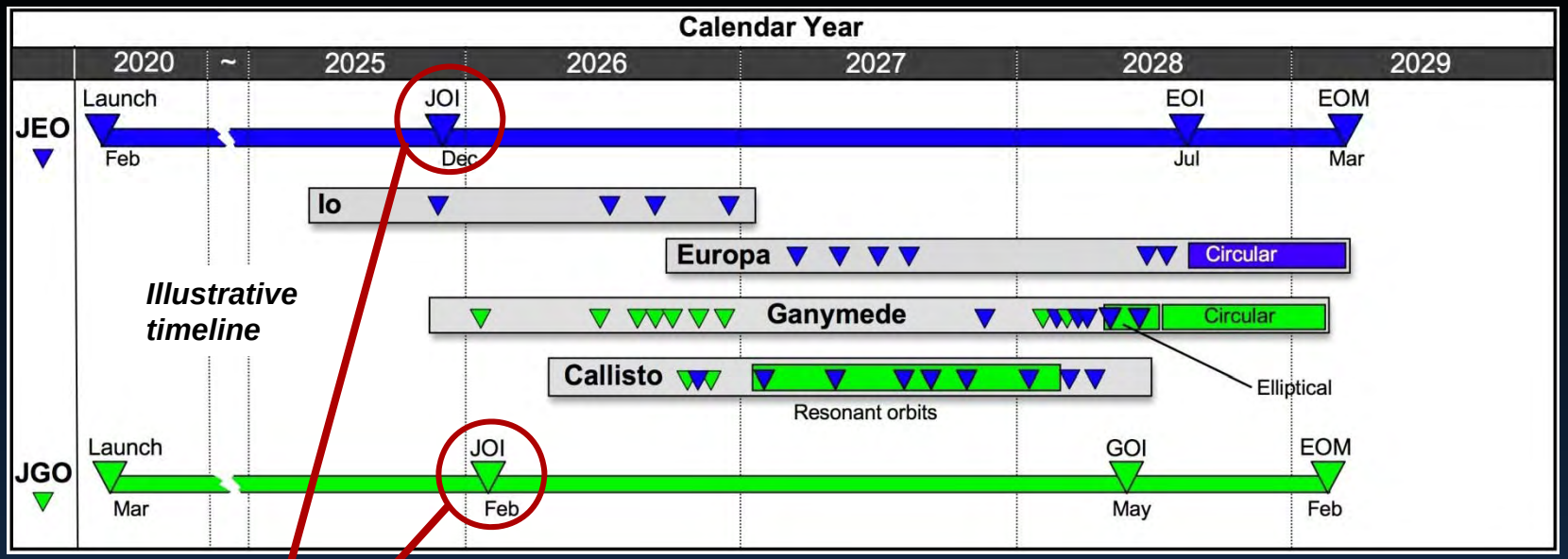
Probing the most powerful planetary magnetosphere and its unique satellite interactions

EJSM Synergistic Science

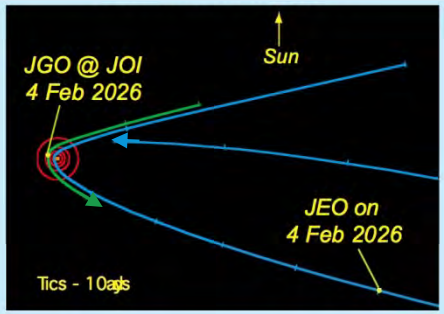


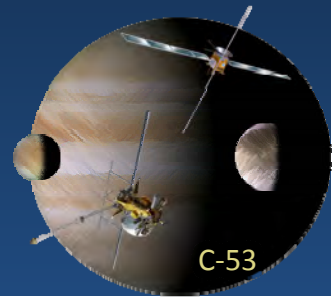


EJSM Synergistic Science



Jupiter Magnetosphere Studies





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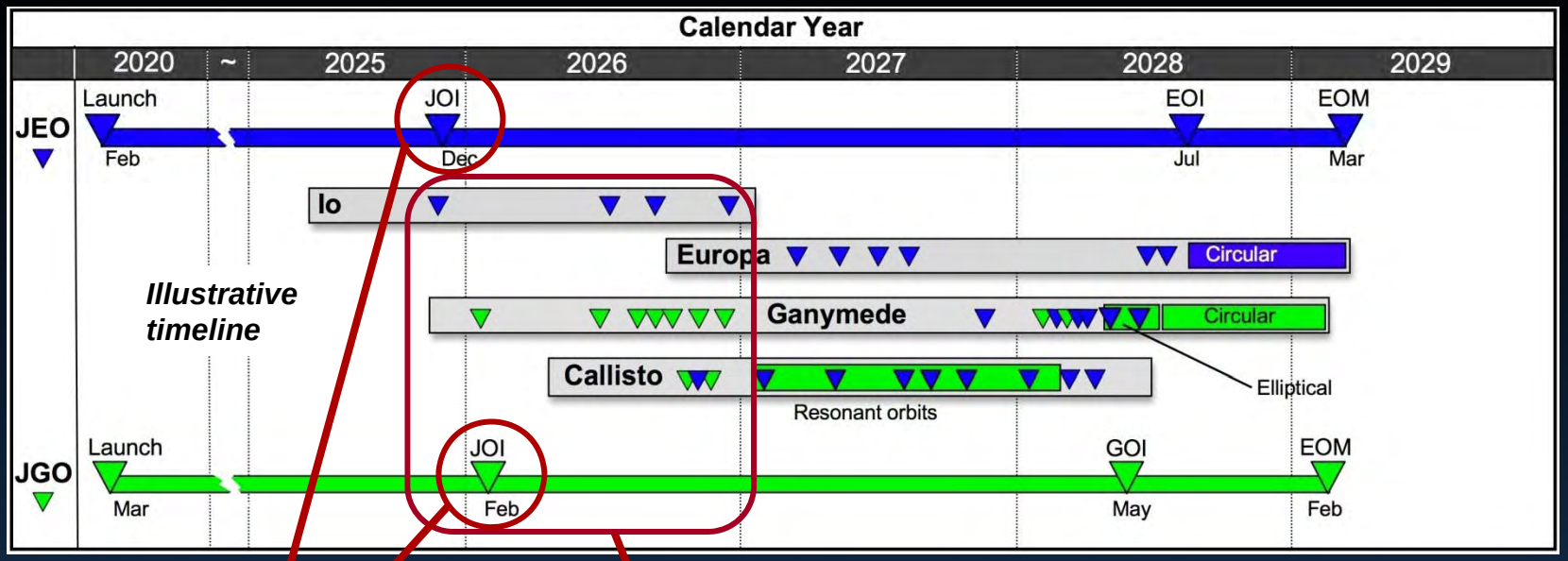
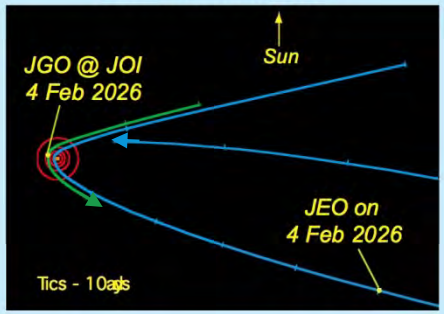
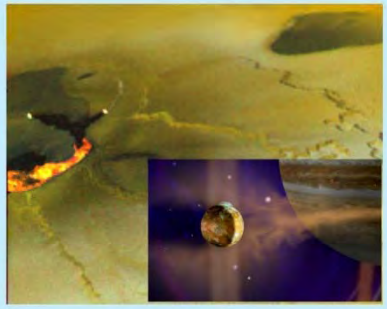
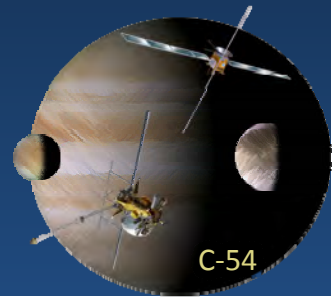


Jupiter Magnetosphere Studies



Io Volcanism & Io Torus Dynamics





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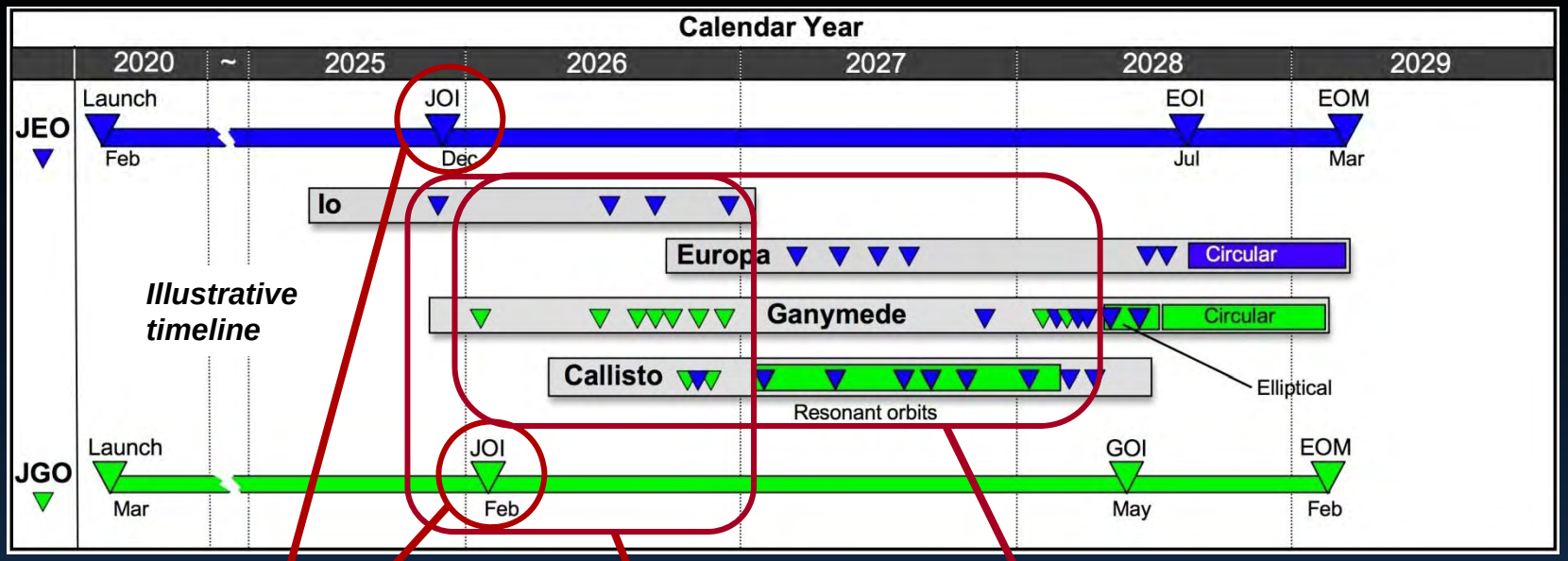
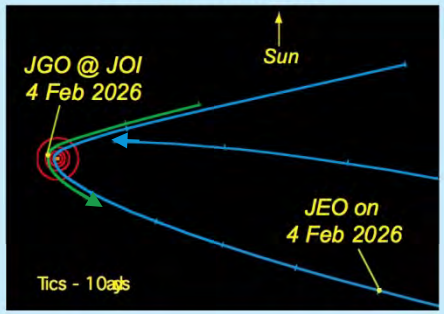
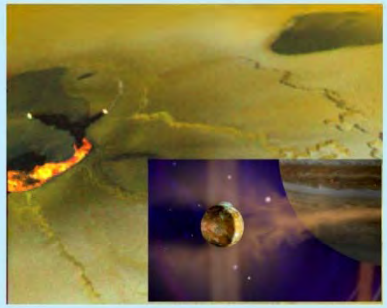


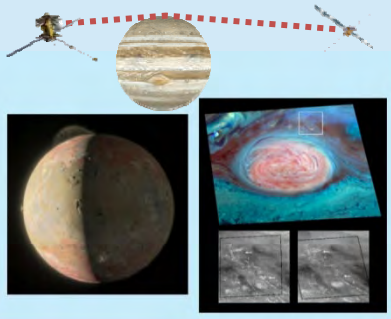
Jupiter Magnetosphere Studies

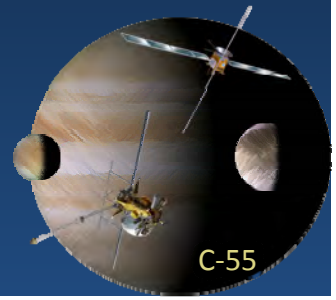


Io Volcanism & Io Torus Dynamics

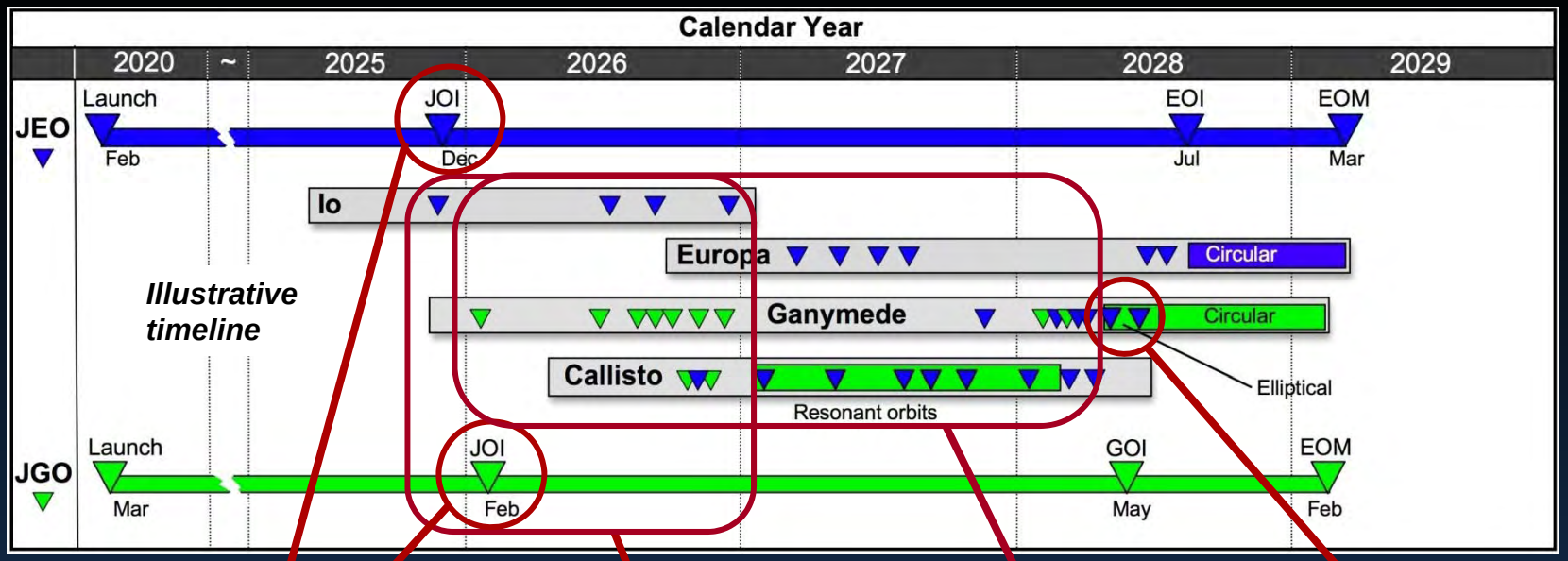


Satellite & Jupiter Monitoring; Radio Occultation Science

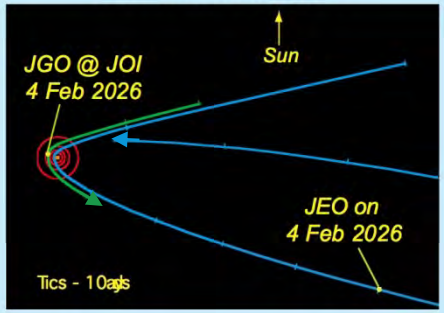




EJSM Synergistic Science



Jupiter Magnetosphere Studies



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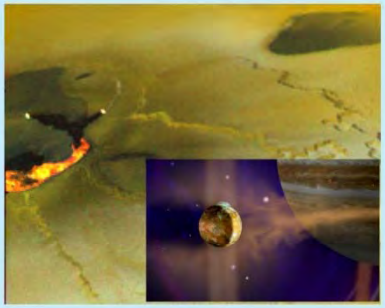

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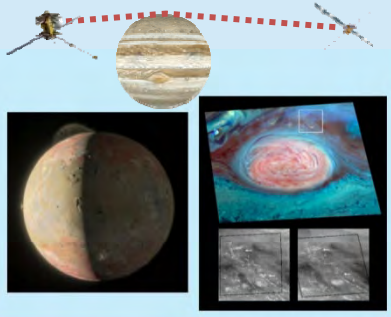
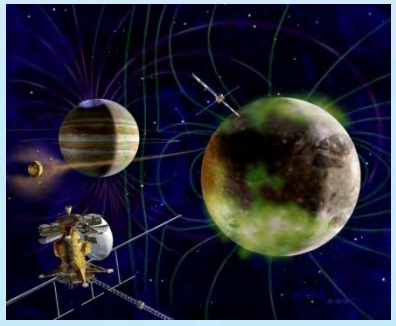
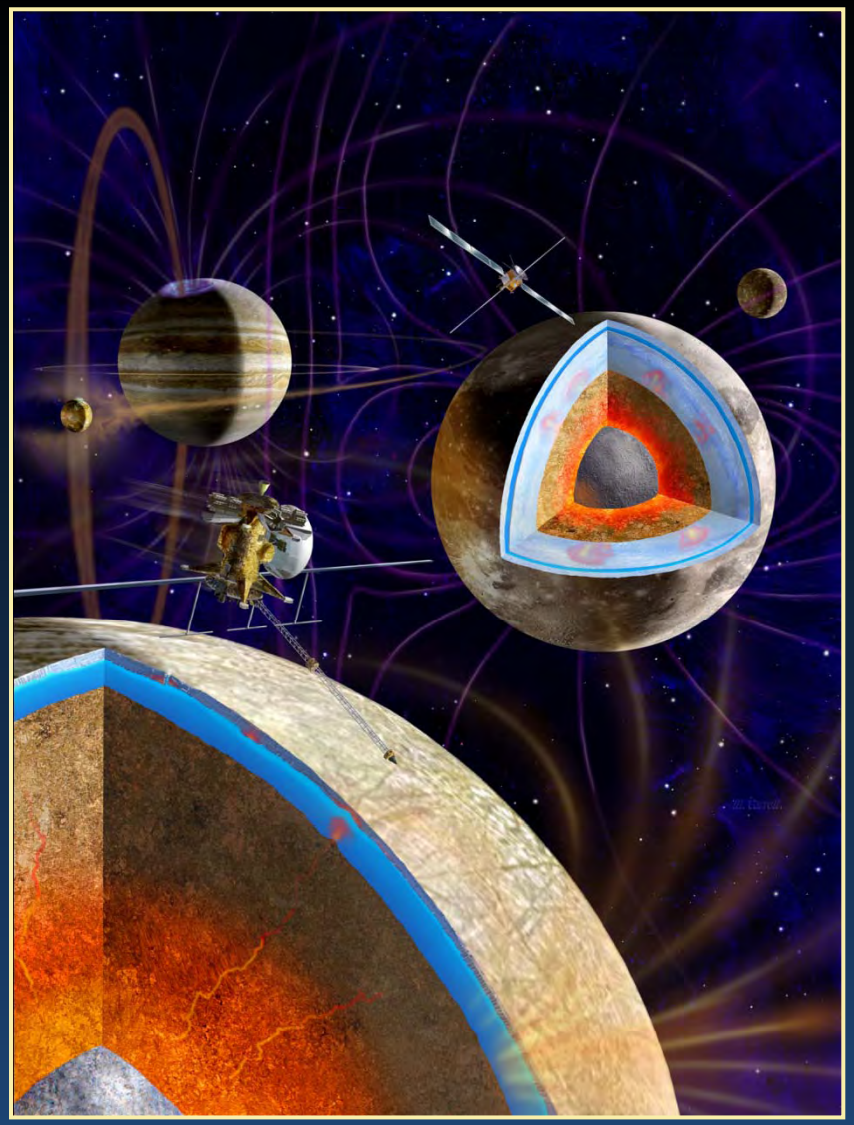


Ganymede Magnetosphere Studies



EJSM Science: Summary



- High-level science goals trace from guiding documents
  - Habitable worlds
  - Jupiter system processes
- Scientific synergies across instruments and spacecraft
  - Instruments would work together to address each science investigation
  - JEO and JGO would perform unique dual-platform synergistic science
- Exploring Europa, Ganymede, and the Jupiter System together
  - One mission with two spacecraft
  - Cooperation and collaboration across the mission